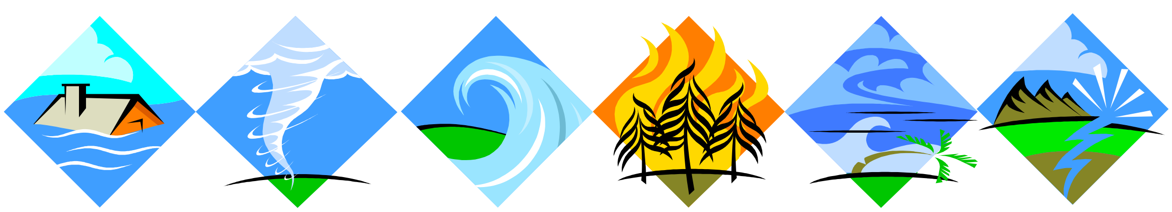
Roanoke Valley-Alleghany Regional Commission

Regional Pre-Disaster Mitigation Plan



Prepared by:
Roanoke Valley-Alleghany Regional Commission

September 6, 2005

Roanoke Valley-Alleghany Regional Commission
Pre-Disaster Planning Committee

Ryan Muterspaugh, Director of Public Safety
Alleghany County

Spencer Suter, GIS - Communications Manager
Botetourt County

Tom Harris, Town Manager
Town of Clifton Forge

John Hudson, Emergency Services Department Coordinator
City of Covington

Jim Cady, Director of Emergency Systems
Craig County

Alan Williams, Mayor
Town of Iron Gate

Jay Taliaferro, Assistant City Manager
City of Salem

Pat Counts, Fire Chief
City of Salem

Charles Van Allman, Jr., City Engineer
City of Salem

Joe Coyle, Emergency Management Coordinator
City of Roanoke

Paul Truntich, Environmental Administrator
City of Roanoke

John Chambliss, Assistant County Administrator
Roanoke County

Anita McMillan, Planning and Zoning Director
Town of Vinton

George Simpson, Assistant Director of Community Development
Roanoke County

Roanoke Valley-Alleghany Regional Commission Planning Staff

John Hull, Regional Planner
Matt Miller, Manager of Information Services
Eddie Wells, Senior Planner

The Committee would also like to thank the following for their input and comments during the planning process:

Doris England, Department of Emergency Services, City of Roanoke

Ned McElwaine, Deputy County Administrator, Botetourt County

Greg Reed, Engineering Department, City of Roanoke

Wanda Reed, City of Roanoke

Bob Boeren, Virginia Department of Forestry

Joey Stump, Division Chief, Roanoke County Fire and Rescue Department

Lisa Link, Roanoke Regional Chamber of Commerce

Charles Hutsell, Virginia Department of Forestry

Rick Hall, Assistant County Administrator, Alleghany County

Chazy Nicely, Iron Gate Volunteer Fire Department

David Chaplin, Roanoke County Fire and Rescue Department

EXECUTIVE SUMMARY

The Disaster Mitigation Act of 2000 (DMA 2000) requires that local governments, as a condition of receiving federal disaster mitigation funds for Presidential Disaster Declarations, have a mitigation plan that describes the process for identifying hazards, risks and vulnerabilities, identifies and prioritizes mitigation actions, encourage the development of local mitigation and provide technical support for those efforts. The Roanoke Valley-Alleghany region has had eleven (11) Presidential Disaster Declarations since 1969.

The Federal Emergency Management Agency (FEMA) defines *Mitigation* as any sustained action taken to reduce or eliminate long-term risk to life and property from a hazard event. Mitigation, also known as prevention, encourages long-term reduction of hazard vulnerability. The goal of mitigation is to save lives and reduce property damage. Mitigation can accomplish this, and should be cost-effective and environmentally sound. This, in turn, can reduce the enormous cost of disasters to property owners and all levels of government. In addition, mitigation can protect critical community facilities, reduce exposure to liability, and minimize community disruption. Examples include land use planning, adoption of building codes, and elevation of homes, or acquisition and relocation of homes away from floodplains.

It has been demonstrated time after time that hazard mitigation is most effective when based on an inclusive, comprehensive, long-term plan that is developed before a disaster actually occurs. However, in the past, many communities have undertaken mitigation actions with good intentions but with little advance planning. In some of these cases, decisions have been made "on the fly" in the wake of a disaster. In other cases, decisions may have been made in advance but without careful consideration of all options, effects, and/or contributing factors. The results have been mixed at best, leading to less than optimal use of limited resources.

The purpose of this plan is to fulfill local Pre-Disaster Mitigation Plan requirements. The plan will identify hazards; establish community goals and objectives and select mitigation activities that are appropriate for the Roanoke Valley-Alleghany Region.

Planning Area

The Regional Pre-Disaster Mitigation Plan affects unincorporated areas, towns, cities and counties within the Roanoke Valley-Alleghany Regional Commission service area. While the plan does not establish any legal requirements for the localities, it does provide a framework for planning for natural hazards.

The localities addressed in this plan include: the counties of Alleghany, Botetourt, Craig and Roanoke; the cities of Covington, Roanoke and Salem; and the towns of Buchanan, Clifton Forge, Fincastle, Iron Gate, New Castle, Troutville and Vinton.

Hazards

The natural hazard most likely to affect the Roanoke Valley-Alleghany region is widespread ***flooding*** or flash flooding. Watersheds in the Roanoke Valley-Alleghany region are typical of the Blue Ridge region in which smaller streams collect water which then flows through steep terrain, picking up velocity, and into the valleys and flatlands along major rivers where development has occurred.

In the Roanoke Valley ***wildfires*** are second only to flooding as the greatest recurring natural hazard. In 1999, Fort Lewis Mountain in the western part of Roanoke County burned out of control for a week, destroying land and endangering homes before it was brought under control.

The area is frequently subjected to ***winter storms***, heavy thunderstorms, tropical storms, ***hurricane*** remnants, ***landslides, karst*** and occasional ***tornado***. Meteorological events have the potential to impact all communities and structures in the Roanoke Valley-Alleghany region.

The Regional Mitigation Plan

The purpose of this planning initiative is to develop a Plan that meets all State and Federal requirements. The Plan will help localities maintain their eligibility for certain future Federal funding, especially the Hazard Mitigation Grant Program. A FEMA-approved Mitigation Plan is also required to participate in the Emergency Management Performance Grant Program and in projects under the Pre- Disaster Mitigation Grant Program.

The plan outlines general actions designed to address and reduce the impact of a full range of natural hazards facing region, including such natural hazards as floods, hurricanes, winter storms and wildfires. A multi-jurisdictional planning approach was utilized. By having multiple jurisdictions work together on common hazards/risks, the planning process eliminated the need for each local jurisdiction to devise its own approach and prepare its own separate document. Further, this type of planning effort resulted in a common plan format and loss estimation technique that will help the State Department of Emergency Management and FEMA understand the area's vulnerabilities when evaluating future policies and projects.

While a single, regional plan was developed, please note that *each local jurisdiction has its own separate section as part of the overall plan.*

Hazard Identification

The RVARC worked with the Regional Pre-Disaster Mitigation Plan Committee to compile data on natural hazards. Information was compiled on the occurrence of natural hazard events in the region. Hazards that affect the area were identified based on historical and other available data. Each local jurisdiction has been given an opportunity to review the hazard events data and make amendments as appropriate.

Risk Assessment And Loss Estimates

RVARC assessed potential impacts from each hazard using available geographic information system (GIS) layers and government databases. Loss estimates were performed only for flooding. Other disasters are too variable and widespread to determine any useful loss estimates.

Mitigation Strategy Development

Based on the findings of the risk assessment, RVARC, working with local governments, drafted an overall mitigation strategy for the region and each individual locality. During this step, goals, objectives and actions to reduce the damage from each hazard were identified for the planning area.

Public Participation

Localities, state and federal agencies, and other local groups were invited to serve on the Roanoke Valley-Alleghany Regional Commission Pre-Disaster Mitigation Plan Committee. Local governments were asked to appoint the staff and/or citizens that would be the most appropriate representative(s) to the Committee and responded with a wide range of appointees: Mayors, Emergency Service Coordinators, Engineers, Planners, City and Town Managers, and fire and rescue personnel. Locality representatives attended the Committee meetings on a regular basis. Additional groups that the Committee felt would be of assistance were also invited to participate. These included local Chambers of Commerce, the local Chapter of the Red Cross, Virginia Department of Forestry, U.S. Forest Service, and the Council of Community Services. Committee meetings were held on an as needed basis at critical times in the document's development and for review of the draft and final versions of the Plan. Committee meeting agendas and attendance sheets are included in this appendix.

The public was invited to attend one or more of four open-house format workshops that were held to seek input about hazards that have impacted the area. Participants were given the opportunity to review maps, historical hazard data, damage estimates, and information about the Disaster Mitigation Act and the pre-disaster planning requirements. Information gathered at the workshops was used in developing strategies to mitigate natural hazards in the region.

Workshops were held in the early evening, two from 5 to 7 p.m. and two from 6 to 8 p.m., over a three-week period. The workshops were advertised as display ads in two daily and four weekly local newspapers. The workshops, and the mitigation plan process itself, were covered by the local newspapers, local radio news broadcasts and a local chamber of commerce newsletter. A Public Forum for review of the final draft of the Plan was held August 29, 2005 at the Roanoke Higher Education Center. Workshop announcements, sign-in sheets, news articles, brochures, and handout materials are included in Appendix A.

Plan Review, Adoption and Maintenance

In accordance with Federal and State requirements, the governing bodies of each participating jurisdiction must review and approve that portion of the overall plan that affects their jurisdiction. FEMA has requested that each locality review the final version of the plan and adopt it by resolution. The plan will then be sent to the Virginia Department of Emergency Management and FEMA for review and approval.

Following FEMA approval, the plan may then be officially adopted by each locality. No changes to the plan should be made following FEMA's approval of the document. If changes are necessary, they should be noted in the resolution and addressed in the next plan update.

The Plan Maintenance section of this document, Chapter 8, details the process that will ensure that the Mitigation Plan remains an active and relevant document. The process includes a schedule for monitoring the Plan on an annual basis and producing the required plan revision every five years and describes how the localities will integrate public participation throughout the plan maintenance process.

(Remainder of page intentionally left blank)

Table of Contents

List of Tables

List of Figures

Appendices

(Blank)

Chapter 1
Introduction

Natural Hazards Mitigation Planning

The Disaster Mitigation Act of 2000 (DMA 2000) requires that local governments, as a condition of receiving federal disaster mitigation funds, have a mitigation plan that describes the process for identifying hazards, risks and vulnerabilities, identifies and prioritizes mitigation actions, encourage the development of local mitigation and provide technical support for those efforts.

The Federal Emergency Management Agency (FEMA) defines *Mitigation* as any sustained action taken to reduce or eliminate long-term risk to life and property from a hazard event. Mitigation, also known as prevention, encourages long-term reduction of hazard vulnerability. The goal of mitigation is to save lives and reduce property damage. Mitigation can accomplish this, and should be cost-effective and environmentally sound. This, in turn, can reduce the enormous cost of disasters to property owners and all levels of government. In addition, mitigation can protect critical community facilities, reduce exposure to liability, and minimize community disruption. Examples include land use planning, adoption of building codes, and elevation of homes, or acquisition and relocation of homes away from floodplains.

It has been demonstrated time after time that hazard mitigation is most effective when based on an inclusive, comprehensive, long-term plan that is developed before a disaster actually occurs. However, in the past, many communities have undertaken mitigation actions with good intentions but with little advance planning. In some of these cases, decisions have been made "on the fly" in the wake of a disaster. In other cases, decisions may have been made in advance but without careful consideration of all options, effects, and/or contributing factors. The results have been mixed at best, leading to less than optimal use of limited resources.

Planning Process

The purpose of this plan is to fulfill local Pre-Disaster Mitigation Plan requirements. The plan will identify hazards; establish community goals and objectives and select mitigation activities that are appropriate for the Roanoke Valley-Alleghany region.

The Regional Pre-Disaster Mitigation Plan affects unincorporated areas, towns, cities and counties within the Roanoke Valley-Alleghany Regional Commission service area. While the plan does not establish any legal requirements for the localities, it does provide a framework for natural hazard mitigation planning.

Committee Meetings

Committee meetings were held on an as needed basis at critical times in the document's development and for review of the draft and final versions of the Plan. Committee meeting agendas and attendance sheets are included in Appendix A.

Localities, state and federal agencies, and other local groups were invited to serve on the Roanoke Valley-Alleghany Regional Commission Pre-Disaster Mitigation Plan Committee. Local governments were asked to appoint the staff and/or citizens that would be the most appropriate representative(s) to the Committee and responded with a wide range of appointees: Mayors, Emergency Service Coordinators, Engineers, Planners, City and Town Managers, and fire and rescue personnel. Locality representatives attended the Committee meetings on a regular basis.

Additional groups that the Committee felt would be of assistance were also invited to participate. These included local Chambers of Commerce, the local Chapter of the Red Cross, Virginia Department of Forestry, U.S. Forest Service, and the Council of Community Services. The Council of Community Services (over 70 community organizations) provides a forum for coordination of access to human services information, and uses its resources to assist organizations and decision makers in planning for and meeting emerging human needs to improve the quality of life in the community. Chambers of Commerce were invited to participate and asked to notify their members, through newsletters or web sites, about the mitigation plan. Chambers of Commerce included the Alleghany Highlands Chamber of Commerce, the Botetourt County Chamber of Commerce, the Roanoke Regional Chamber of Commerce and the Salem-Roanoke County Chamber of Commerce. The Virginia Department of Forestry and U.S. Forest Service attended the initial Committee meetings and provided valuable data concerning wildfire hazards in the region.

Public Participation

The public was invited to attend one or more of four open-house format workshops that were held to seek input about hazards that have impacted the area. Participants were given the opportunity to review maps, historical hazard data, damage estimates, and information about the Disaster Mitigation Act and the pre-disaster planning requirements. Information gathered at the workshops was used in developing strategies to mitigate natural hazards in the region.

Workshops were held in the early evening, two from 5 to 7 p.m. and two from 6 to 8 p.m., over a three-week period. The workshops were advertised as display ads in two daily and four weekly local newspapers. The workshops, and the mitigation plan process itself, were covered by the local newspapers, local radio news broadcasts and a local chamber of commerce newsletter. A workshop to present the final draft of the Plan to the public was held August 29, 2005. Workshop announcements, sign-in sheets, news articles, brochures, and handout materials are included in this appendix.

Roanoke Valley-Alleghany Regional Commission
Pre-Disaster Mitigation Plan Meetings

Date	Group	Location
December 6, 2002	Committee	RVARC Board Room
May 1, 2003	Committee	RVARC Board Room
August 19, 2003	Public Workshop	Fincastle Volunteer Fire Department, Fincastle, VA
August 21, 2003	Public Workshop	Alleghany County Governmental Complex, Low Moor, VA
September 2, 2003	Public Workshop	Craig County Municipal Building, New Castle, VA
September 4, 2003	Public Workshop	Roanoke County Public Library, Roanoke, VA
October 31, 2003	Committee	RVARC Board Room
December 12, 2003	Committee	RVARC Board Room
February 17, 2005	Committee	RVARC Board Room
June 2, 2005	Committee	RVARC Board Room
June 17, 2005	Committee	RVARC Board Room
August 25, 2005	Committee	RVARC Board Room
August 29, 2005	Public Workshop	Roanoke Higher Education Center

Plan Review

The planning process included an opportunity for adjacent localities and regional commissions to review the draft plan. The following Virginia jurisdictions were contacted: Bath County, Bedford County, Floyd County, Franklin County, Giles County, Montgomery County, and Rockbridge County. In West Virginia, Greenbrier County and Monroe County were notified that the plan was available for review.

The New River Valley Planning District Commission, Central Shenandoah Planning District Commission, Region 2000 Regional Commission, and West Piedmont Planning District Commission were notified of the availability of the draft plan and given an opportunity to comment. The West Virginia regional commissions adjacent to the planning area - Region 1–Planning and Development Council (Princeton, WV) and Region 4–Planning and Development Council (Summersville, WV) – were contacted for their comments.

Institutions of higher learning within the Roanoke Valley-Alleghany Regional Commission area that were contacted for their comments included Virginia Western Community College, Dabney S. Lancaster Community College, Roanoke College and Hollins University.

Regional Profile

The Roanoke Valley-Alleghany Regional Commission service area lies in western Virginia and includes the counties of Alleghany, Botetourt, Craig and Roanoke; the cities of Covington, Roanoke and Salem; and the towns of Buchanan, Clifton Forge, Fincastle, Iron Gate, New Castle, Troutville, and Vinton.

<u>Location</u>

The region is on the eastern border of the Appalachian Plateau and the western slope of the Blue Ridge Mountains. The James River flowing east through Botetourt County ultimately reaches the Chesapeake Bay and Atlantic Ocean. The Roanoke River flows through the district in a southeasterly direction to North Carolina before reaching the Atlantic. Both river basins serve as development corridors. Although the planning area includes the Roanoke metropolitan area, much of the region is rural. Approximately 212,039 acres of land lies within the National Forest and Blue Ridge Parkway system.

Figure 1
Planning Area

Physiography

The predominant physical characteristic of the region is the mountainous terrain. Forty-eight percent of the land area has slopes of 25 percent or greater. Within the region mountain ridges run southwest to northeast. There are large concentrations of steep land in northern Botetourt County and Alleghany County. A broken ring of steep lands surrounds the Roanoke metropolitan area. Past development has been influenced greatly by topographic characteristics. The higher elevations have remained in open or forest use while the more moderate foothills and river valleys have been developed.

Flood plains impose considerable restraints on land development activities. In the past, heavy flooding has caused considerable property damage to existing development in flood plains. The region has several major flood plain areas along the Roanoke, James and Jackson Rivers, Peters, Mason, Carvin, Tinker, Glade, Mud Lick and Smith Creeks.

Transportation

Interstate 64 bisects Alleghany County in an east-west direction while passing through the City of Covington and Town of Clifton Forge. Interstate 81 crosses Botetourt and Roanoke counties in a northeast-southwest direction and includes an urban connector I-581 that links I-81 to the central business district of the City of Roanoke. Other arterial routes in the area include US 11 in Botetourt and Roanoke counties; US 60 in Alleghany County; US 220 passing through Alleghany, Botetourt, and Roanoke counties; US 221 and 460 in Roanoke County; and State Primary Route 311 in Alleghany and Craig counties.

Climate

The climate of the region is mild and characterized by warm summers and moderately cool winters. Average monthly temperatures range from a low of 36 F in January to a high of 73 F in July. The average annual temperature is 54 F. Annual precipitation is 43 inches and proportionate throughout the year. The highest monthly rainfalls occur between May and September. Snowfall amount averages 20 inches per year.

Population

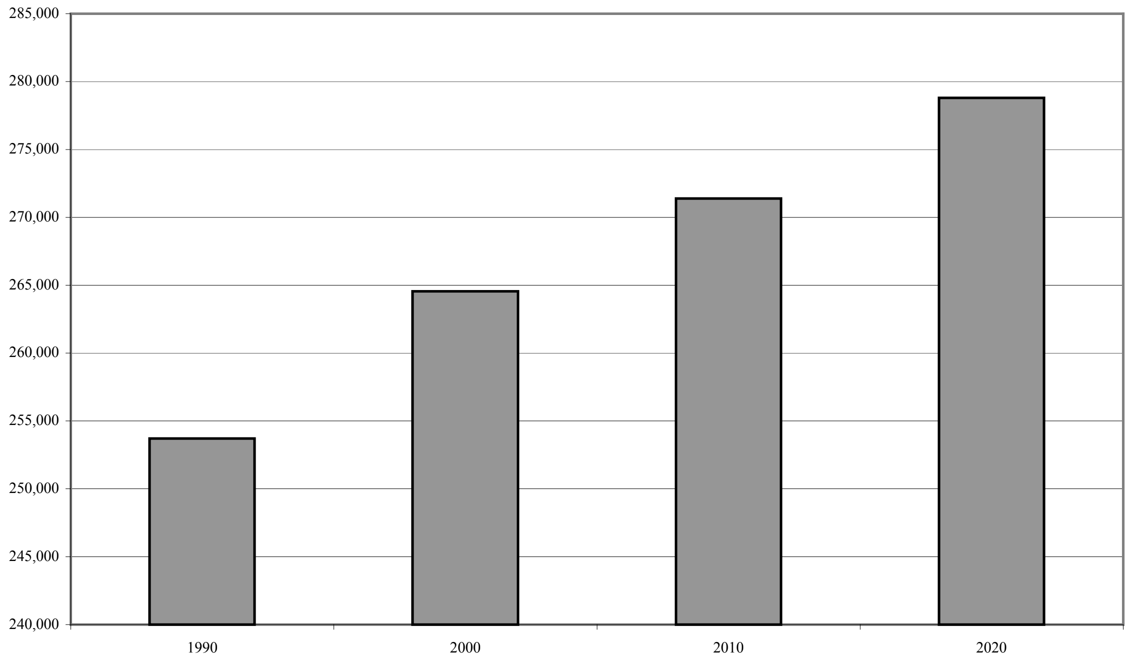
The district has an area of 1,636 square miles and a 2000 population of 264,541 according to the US Census Bureau. The region's population is projected to increase to 278,800 by 2020 based on estimates from the Virginia Employment Commission. There are 110,228 occupied residences valued at more than $9 billion with an average owner-occupied house value of $82,605. The existing population of the region is concentrated within the Roanoke Valley. The two population centers in the region are the Roanoke Valley area and the Covington/Clifton Forge area.

Table 1
Locality Population Trends

Locality	1990	2000	Percent Change
Alleghany County	13,176	12,926	-1.9%
Botetourt County	24,992	30,496	22.0%
Town of Buchanan	1,222	1,233	0.9%
Town of Clifton Forge	4,679	4,289	-8.3%
City of Covington	6,991	6,303	-9.8%
Craig County	4,372	5,091	16.4%
Town of Fincastle	236	359	52.1%
Town of Iron Gate	417	404	-3.1%
Town of New Castle	152	179	17.8%
City of Roanoke	96,509	94,911	-1.7%
Roanoke County	79,294	85,778	8.2%
City of Salem	23,797	24,747	4.0%
Town of Troutville	455	432	-5.1%
Town of Vinton	7,643	7,782	1.8%

Source: Census of Population, U.S. Census Bureau, 1990 and 2000.
Note: Town populations are included in County totals.

Figure 2
Regional Population Trend
Roanoke Valley-Alleghany Region
1990 – 2020



Source: Census of Population, U.S. Census Bureau, 1990 and 2000 and Population Projections, Virginia Employment Commission, 2003.

Chapter 2
Hazard Specific Information

Hazards

The region has experienced nearly all types of natural disasters, the major ones being flooding, landslides, winter storms, and wildfires. Other disasters that might occur in the region include earthquakes, hurricanes, and tornados. Based on past occurrences and probability the Pre-Disaster Planning Committee selected the following disasters for inclusion in this Plan: earthquakes, flooding, hurricanes, karst, landslides, tornados, wildfires, and winter storms. There were no locality specific unique hazards identified during the planning process.

The natural hazard most likely to affect the Roanoke Valley-Alleghany region is widespread ***flooding*** or flash flooding. Watersheds in the Roanoke Valley Alleghany Regional Commission region are typical of the Blue Ridge region in which smaller streams collect water which then flows through steep terrain, picking up velocity, and into the valleys and flatlands along major rivers where development has occurred

In the Roanoke Valley ***wildfires*** are second only to flooding as the greatest recurring natural hazard. In 1999, Fort Lewis Mountain in the western part of Roanoke County burned out of control for a week, destroying land and endangering homes before it was brought under control. Other fires have occurred on Brushy Mountain, Poor Mountain, Twelve O'clock Knob, Yellow Mountain, and even portions of Mill Mountain that lies within the heart of the City of Roanoke. The Purgatory Mountain fire in Botetourt County burned 1,285 acres and cost over $166,000 to contain.

Floods are not the only weather related disasters the Region faces. The area is frequently subjected to ***winter storms***, heavy thunderstorms, tropical storms, ***hurricane*** remnants, ***karst topography***, ***landslides*** and occasional ***tornado***. Meteorological events have the potential to impact all communities and structures in the Roanoke Valley-Alleghany Regional Commission region.

Hurricanes or tropical storms occur when their track inland from the Atlantic or Gulf Coast brings them into the surrounding Blue Ridge Mountains. The long periods of rain result in mountain streams overflowing and urban stormwater facilities exceeding their capacities. Thunderstorms often can create flash flooding in the area. Several neighborhoods throughout the region experience flash flooding every year due to runoff resulting from strong thunderstorms. These flash floods can damage homes, washout roads and overflow stormwater systems.

Thunderstorms bring large amounts of rain, lightning and damaging winds. Thunderstorm season in the region is spring to late fall. Straight-line winds and flooding are responsible for most thunderstorm damage. Severe thunderstorms have produced tornados in the region. The last verified tornado in the region occurred in 2003 and had winds of 110-113 miles per hour. Landslides can occur during or following intense thunderstorms or prolonged rain events such as hurricanes. Landslides can damage buildings located on steep slopes and block roadways.

Artic blasts and Gulf moisture have historically combined to deliver serious winter weather to the region. There is potential for dangerous winter weather from November to May. The regions greatest snowfalls occur from January to March. In 1966, the Roanoke Valley received 41.2 inches of snow. When heavy snowfalls occur, highway crews, emergency personnel and citizens can quickly become overwhelmed - roads close, rescue personnel are pushed to the limit, and citizens can be stranded at work or at home. Heavy snow and ice accumulation can knock down trees, power and telephone lines, and collapse roofs. Winter ice storms are frequent in the region. Even modest accumulations of ice can knock down trees, power lines, and communication towers that are critical for emergency services.

Earthquake

An earthquake is a sudden, rapid shaking of the Earth caused by the breaking and shifting of rock beneath the Earth's surface. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface move slowly over, under, and past each other. Sometimes the movement is gradual. At other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free causing the ground to shake. Most earthquakes occur at the boundaries where the plates meet; however, some earthquakes occur in the middle of the plates.

Ground shaking from earthquakes can collapse buildings and bridges; disrupt gas, electric, and phone service; and sometimes trigger landslides, avalanches, flash floods, fires, and huge, destructive ocean waves (tsunamis). Buildings with foundations resting on unconsolidated landfill and other unstable soil, trailers and homes not tied to their foundations are at risk because they can be shaken off their mountings during an earthquake. When an earthquake occurs in a populated area, it may cause deaths and injuries and extensive property damage.

Ground movement during an earthquake is seldom the direct cause of death or injury. Most earthquake-related injuries result from collapsing walls, flying glass, and falling objects as a result of the ground shaking, or people trying to move more than a few feet during the shaking. Much of the damage in earthquakes is predictable and preventable. We must all work together in our communities to apply our knowledge to building codes, retrofitting programs, hazard hunts, and neighborhood and family emergency plans.

Past Events

Virginia, like most states on the eastern seaboard, has a moderate level of risk from earthquakes. The largest earthquake known to have occurred in the region was the 1886 Charleston, South Carolina, earthquake (estimated magnitude 6.6-6.9). That quake was felt as far north as Canada, as far west as Missouri, and as far south as Cuba. Although earthquakes outside Virginia (e.g. 1886 Charleston, South Carolina) have caused damage in the Commonwealth in the past, the most likely sources for future damaging shaking in Virginia are the local active areas within the state like Central Virginia and Giles County.

Since 1774, the year of the earliest documented Virginia earthquake, there have been over 300 earthquakes in or near the Commonwealth. Of those, 18 earthquakes had reports of intensity VI or higher. The largest earthquake in Virginia was the 1897 Giles County shock. The maximum intensity was VIII in Giles County, and it was felt over 11 states (approximately 280,000 square miles). The estimated magnitude for this event was 5.8, making it the third largest earthquake in the eastern United States in the last 200 years (second largest in the southeastern U.S.). From 1978 through 1993, over 160 earthquakes were detected in and around the Commonwealth. The largest earthquake detected since 1978 was the 1984 Cunningham, Virginia earthquake with a magnitude of 4.0, a maximum intensity of V, and was felt over 12,000 square miles.

Table 2
Earthquake Magnitude Classes

Classification	Magnitude
Great	Magnitude > =8
Major	7 < =Magnitude < 7.9
Strong	6 < = Magnitude < 6.9
Moderate	5 < =Magnitude < 5.9
Light	4 < =Magnitude < 4.9
Minor	3 < =Magnitude < 3.9
Micro	Magnitude < 3

Source: USGS Earthquake Hazards Program FAQ, http://earthquake.usgs.gov/faq, 2003.

Current mitigation in the region consists of monitoring for seismic activity by several agencies. In 1963, as part of the Worldwide Standard Seismograph Network program, seismographs were installed at Georgetown University in Washington, DC, and at Blacksburg, Virginia. In 1977, several more seismographs were installed and operated by Virginia Tech and the Virginia Department of Mines, Minerals, and Energy - Division of Mineral Resources. Initially, the recording was purely analog, but in 1985 digital recording was added. In 1995, a US National Seismic Network broadband, high dynamic range seismograph was installed in Blacksburg. In 1997 the Giles County network was upgraded to digital telemetry.

The Virginia Tech Seismological Observatory (VTSO) operates a digital seismic network with stations in Virginia and southern West Virginia. Along with other southeastern regional seismic networks and the U.S. National Seismic Network (USNSN), VTSO contributes to earthquake monitoring, information dissemination and seismic hazard assessment objectives in the southeastern United States. In 1991, Virginia Tech combined with other institutions in North Carolina and Tennessee to form the Southern Appalachian Cooperative Seismic Network to coordinate earthquake monitoring and data exchange. The VTSO is also a member of the Council of the National Seismic System.

References:

Earthquakes, Matthew S. Sibol and Martin C. Chapman (Seismological Observatory, Virginia Polytechnic Institute and State University) and Stanley S. Johnson (Department of Mines, Minerals and Energy - Division of Mineral Resources), 1994.

Virginia Tech Seismological Observatory, http://www.geol.vt.edu/outreach/vtso, 2001.

National Earthquakes Hazard Reduction Program, Earthquake Hazards Program,
http://earthquake.usgs.gov, 2002.

USGS Earthquake Hazards Program FAQ, http://earthquake.usgs.gov/faq, 2003.

Flood

The disaster most likely to affect the Roanoke Valley-Alleghany region is widespread flooding or flash flooding. Watersheds in the Roanoke Valley-Alleghany region are typical of the Blue Ridge region in which smaller streams collect water which then flows through steep terrain, picking up velocity, and into the valleys and flatlands along major rivers where development has occurred. The flood plains throughout these mountainous areas are narrow, averaging less than 250 feet in most areas. These are also the only flat areas where development could take place in this mountainous region. Most flood-producing storms generally occur in the winter and spring. However, flooding due to intense local thunderstorms or from tropical disturbances can occur in late summer or fall.

Flood hazard areas are shown on the maps in Appendix C of this plan.

Review of Past Events and Reports

A **review of past flood related research** and documentation indicates that there are an estimated 5,400 structures that could be impacted by flooding in the Roanoke Valley Alleghany Region. The following documents chronicle flood events in the Roanoke Valley-Alleghany Regional Commission region: Flood Plain Information reports developed by the U.S. Army Corps of Engineers (COE) in the 1968-1971 covering the Roanoke River (City of Roanoke, Roanoke County and City of Salem), Mason Creek (Salem), James River (Alleghany County, Covington, Clifton Forge, and Botetourt County), Jackson River (Alleghany County, Covington and Clifton Forge), Smith Creek (Alleghany County and Clifton Forge); Flood Control Study for Covington, U.S. Army Corps of Engineers 1987; Flood Insurance Study, Alleghany County, Virginia, unincorporated areas, FEMA, 1992; Flood Insurance Study, Botetourt County, Virginia unincorporated areas, 1977; Roanoke Valley Regional Stormwater Management Plan, 1977; and Hazard Analysis, Project Impact Roanoke Valley, 2000.

Alleghany County has experienced floods since its original settlement. Large floods occurred in 1877, 1913, 1936, 1969, 1972, 1973 and 1985. Flood damage in the area is typically concentrated in and near Covington and Clifton Forge. Because of the rural nature of the county, damages from flooding are widespread. Damage occurs to roads and bridges and public facilities such as schools.

The Jackson River flows through the City of Covington, towns of Clifton Forge and Iron Gate and the communities of Low Moor and Selma. Gathright Dam, constructed in 1974, partially controls flooding along the Jackson River. However, many structures will continue to be in harms way in the event of a US Army Corps of Engineers projected Standard Project Flood. The water and sewer treatment plants located along the Jackson could be damaged as well as most of the river's bridges.

Covington has experienced large floods on November 1877, March 1913, March 1936, March 1967, August 1969 (Hurricane Camille), 1972 (Tropical Storm Agnes), March and December 1973, and November 1985. Tropical Storm Agnes was the most severe of the events with as much as one-third of the city under water. In all, one church, three public buildings, two industrial plants, 8 commercial buildings, and 490 private residences were damaged. In November 1985, a 100-year frequency rainstorm caused a reported $17 million in damages in the City of Covington. This indicates that even with flood control provided by the dam, the city is still vulnerable to flooding.

The US Army Corps of Engineers, 1986 report titled Flood Control Study, Jackson River, Lower Jackson Street Residential Area, Covington, provides information about the major flood that occurred in November 1985. An approximate 90-year flood event resulted in residential, commercial, and municipal damage in the lower Jackson Street / Rayon Terrace neighborhood. Residential losses included yard, basement, and first floor damage in sixty-four (64) homes and four (4) businesses. Municipal damage included debris in the city park, a sewage pump station and damage to a storm sewer. Total residential, commercial and municipal damage were estimated at $544,000. *Structural and non-structural alternatives for this section of the city were explored in a cost-benefit analysis and found to be infeasible.*

The Army Corps of Engineers 1986 Flood Control Study, Harmon's Run at Industrial Park, Covington, Virginia, reports that the 1985 flood caused inundation of the industrial park's southern edge and affected nothing of value at the site. *The study concluded that no benefits would be realized for a flood-proofing project due to the lack of damage from the flood.*

Floods used in the 1978 Federal Insurance Administration study to describe the impact on the town of Clifton Forge include the Flood of 1950 and Flood of 1969 – both which occurred prior to construction of Gathwright Dam. The 1950 flood brought on the flooding of basements, a lumberyard and the armory, and the town's water supply was cut off when two water mains were washed away.

Smith Creek flows north to south though the residential and commercial center of the Town of Clifton Forge. In Clifton Forge, residential, public, and commercial development are concentrated on both sides of Smith Creek. A number of large commercial buildings in the downtown area have been constructed directly over Smith Creek. Floods have inundated portions of this land in the past, and a substantially greater area is within reach of larger floods in the future. The 1969 Smith Creek flooding caused evacuation of 40 families; a water main was broken, damaged the Matthews Woodworking Mill and caused over $200,000 in damage to town owned property. Little data is available to document the flood events along Smith Creek. Because of the watersheds steep slopes with the town, flood velocities could be dangerously high and cause substantial damage.

Numerous flood events have been recorded in the Upper James River Basin in the counties of Alleghany, Botetourt and Craig. The following water bodies in the basin have flooded: Dunlap Creek, Potts Creek, Cowpasture River, Johns Creek, Craig Creek, and Catawba Creek. Records show a history of major and frequent flooding. One of the worst floods to occur in Tinker Creek in Botetourt County was in 1940. Another large flood occurred in 1961 along Buffalo Creek and is considered to be one of the worst storms of record. The unincorporated communities of Eagle Rock, Glen Wilton, and Gala located in Botetourt County along the James River have all experienced flooding. Glen Wilton was isolated in 1972 due to floodwaters covering the only road access to the community. The Botetourt Communities of Strom, Lithia, Cloverdale, and Coyner have also been victims of floodwaters.

A lack of flood plain information studies for Craig County prevents damages within this locality from being quantified at this time. The county should work with the Corps of Engineers, Virginia Department of Emergency Management, and FEMA to develop a Flood Insurance Study for the major watersheds of Johns Creek, Craig Creek, Potts Creek, Sinking Creek and Barbours Creek.

The Flood Insurance Study, Botetourt County, Virginia Unincorporated Areas, performed by the US Department of Housing and Urban Development and Federal Insurance Administration in 1977. This flood insurance study covers the unincorporated area of Botetourt County, areas within the incorporated towns of Buchanan, Fincastle, and Troutville are not included. The report studied Back Creek, Buffalo Creek, Craig Creek, Eagle Rock Creek, Ellis Run, Glade Creek, Jackson River, James River, Laurel Run, Laymantown Creek, Long Run, Looney Mill Creek, Mill Creek, Roaring Run, Sinking Creek, and Tinker Creek. One of the worst floods for the James River occurred as a result of Tropical Storm Agnes in 1972. A 1940 event caused severe damage in the Tinker Creek basin. Buffalo Creek was impacted by a flood in 1961. The communities of Eagle Rock, Glen Wilton, and Gala have been in the paths of flood waters associated with both intense summer rainfall and frontal system storms during the winter months. Glen Wilton was isolated in June 1972 due to floodwaters overtopping Route 663. The communities of Strom, Lithia, Cloverdale and Coyner Springs have also been victims of damaging floodwaters.

The James River in Botetourt County has experienced large floods in 1877, 1913, 1936, and 1969. The remains of hurricane Camille in 1969 caused flooding that destroyed homes, roads, railroads, and bridges along the James River.

River stages and discharges on the James River at Buchanan have been recorded since 1895 by the USGS. Since 1877, the bank at full stage of 15 feet has been exceeded at least 60 times. The greatest flood known to have occurred in Buchanan was in November 1877 and measured 34.9 feet at the USGS gage. Other large floods occurred in April 1886, March 1889, March 1902, March 1913, January 1935, March 1936, March 1963, and August 1969. Tropical Storm Agnes in 1972 was the second highest storm of record. Few flood related problems have occurred on Purgatory Creek in the Town of Buchanan because of lack of development in its watershed.

The Town of Buchanan has a primary sewage treatment plant on the James River. The plant is subject to flooding and during the November 1985 flood was out of operation for 6 months. The historic flood of record in Buchanan occurred in November 1985 (after completion of Gathright Dam). The Town of Buchanan was devastated during the November 1985 storm which produced the Flood of Record with an exceedence of 600 years. The river caused water damage and structural damage to numerous buildings. Some buildings were completely washed away. The railroad station was washed off its foundation and the historic footbridge was washed downstream. People who expected their basements to be flooded had water up to their ceilings.

Historic floods in the community of Eagle Rock occurred in November 1985, November 1877, March 1913, June 1972, March 1936, and August 1969. The November 1985 and April 1987 floods were the only two significant flood events to affect the Eagle Rock area since the completion of Gathright Dam. The community of Eagle Rock was severely flooded during the November 1985 storm causing substantial damage to the commercial district and to many residences. The 1985 storm was the storm of record with an exceedence frequency of 460 years. Seventeen commercial properties and about 16 residences were damaged during the November 1985 flood.

The history of flooding in the Roanoke Valley has been well documented since records were kept. Since 1877 over 17 large floods have occurred in the Roanoke Valley with four of the largest in the past 20 years. Dates of significant floods include the following: 1877, August 1892, October 1893, October 1906, Spring 1913, August 1928, October 1932, January 1935, August 1939, August 1940, July 1947, August

1961, July 1962, June 1972, April 1978, November 1985, April 1992, and June 1995. The flood of record was the November 1985 event.

In the past 20 years, four of the largest floods on record have occurred including June 1972, April 1978, November 1985, and April 1992. Based on rainfall amounts and durations which resulted in these events, the June 1972, April 1978, and November 1985 flood events have recurrence intervals, respectively of approximately 50-, 130-, and 10-years. In this period of flood activity, damages have been estimated exceeding $200 million with over 12,000 impacted residential structures and over 1,000 businesses.

In November of 1985 when rains from Hurricane Juan caused the Roanoke River to rise and crest at a level of 23.4 feet from the bottom of the River, as measured from Walnut Street. The result of that single weather event created floodwaters in downtown Roanoke that rose over five feet inside some businesses. Ten lives were lost and damage to property cost $520,000,000 (source: The Roanoke Times, November, 1985). While this was the Flood of Record, is not the only significant flood the Roanoke Valley has experienced over the past 100 years. On August 16th, 1928, the Roanoke River crested at 18.1 feet; twelve years later, on August 14th, 1940, the Valley's river crested at 18.3 feet. On June 21st, 1972, the Roanoke Valley was hit with the effects of Hurricane Agnes, causing the Roanoke River to crest at 19.6 feet. On April 22nd, 1992, the river once again exceeded its banks and spread floodwaters in the Valley when it crested at 18.1 for the second time during the century.

The most severe flooding on the Roanoke River is usually the result of heavy rains associated with tropical storms, while tributary stream flooding is usually the result of local thunderstorms or frontal systems. Flooding along tributaries is compounded when the streams in lower elevations back-up into feeder streams.

Major floods in the area have occurred in 1940 and 1972 with discharges of 24,400 and 28,800 cfs, respectively, as measured at the USGS gage on the Roanoke River at Niagara Dam. On Tinker Creek at Dale Avenue, the August 1940 storm produced a discharge of 9,000 cfs. The flood damage from the August 1940 event was extensive and resulted in major damage to buildings, roads, bridges, and agricultural crops. The 1972 flood on the Roanoke River, which was the result of Tropical Storm Agnes, was estimated as a 50-year flood. Approximately 400 homes were damaged by flooding from Hurricane Agnes in the Roanoke-Salem area.

On November 5, 1985 a 130-year flood event inundated the study area. This flood was caused by the remnants of Hurricane Juan. The flooding inundated much of the downtown area of Roanoke and resulted in 10 deaths. A total of 11 inches of rain fell between Thursday October 31 and the following Monday. The last six inches fell during the last 24 hours of that five-day period.

Flood Plain Information Glade Creek, Vinton, Virginia, U.S. Army Corps of Engineers, 1971. Glade Creek flows through the northern corporate limits of the Town of Vinton. The report covers the areas subject to flooding by Glade Creek from the Botetourt County line to its confluence with Tinker Creek. The width of the flood plain within the study limits of Glade Creek ranges from 300 feet in width to 1,400 feet. Past floods have occurred at an estimated rate of nearly one every three years.

According to the Flood Plain Management Study, Roanoke River, Roanoke County, Cities of Roanoke and Salem, performed by the US Army Corps of Engineers in 1978, the most severe flooding on the Roanoke River usually results from heavy rains associated with tropical storms. The flood of June 1972, resulting from rains associated with Hurricane Agnes, produced the highest stage of record and approximated the 50-year flood level. This floodplain encompasses about 2,000 acres of flat land where more than 40 industrial plants, along with approximately 2,630 homes and 1,260 businesses are subject to flooding according to the 1978 report. The report states that although severe flash floods have occurred on the Roanoke River in the past, it is reasonable to assume that even greater floods can occur. Studies show that the 100-year frequency flood would inundate most of the floodplain to a depth of 5 to 7 feet, with some areas covered by as much as 12 feet of water.

The main flood season for the creeks is spring and summer, with most of the higher floods resulting from intense thunderstorms. Floods above bankfull level have occurred in August 1940, September 1960, August 1961, August 1962, August 1964, July 1965, February 1966 and March 1967.

The 1985 FEMA Flood Insurance Study, Roanoke County, Virginia, Unincorporated Areas, covers the unincorporated areas of Roanoke County. In all, selected segments of 19 streams were studied in detail, these include the Roanoke River, Back Creek, Tinker Creek, Glade Creek, Carvin Creek, Mason Creek, Mudlick Creek, West Fork Carvin Creek, Jumping Run, Dry Branch, Cook Creek, Stypes Branch, Barnhardt Creek, Peters Creek, Ore Branch, Glade Creek, Murray Run, Mudlick Creek Tributary 1 and Mudlick Creek Tributary 2. Low lying areas adjacent to the streams are subject to periodic flooding. The most severe flooding is usually the result of heavy rains associated with tropical storms, while creek flooding is the result of local thunder storms or frontal systems. Major floods have occurred several times in the study area including the 1972 50-year flood event and the 1985 flood of record.

Flood Plain Information, Mud Lick Creek at Roanoke, Virginia, U.S. Army Corps of Engineers, 1971. Mud Lick Creek flows along the western corporate limits of the City of Roanoke. Past floods have occurred at an estimated rate of nearly one every three years.

Special Flood Plain Information, Upper Mason Creek at Roanoke County, Virginia, by the U.S. Army Corps of Engineers and Hayes, Seay, Mattern and Mattern, addresses the flood situation along Mason Creek upstream from the Virginia Route 116 bridge northward and includes the communities of Bennett Springs, Mason Cove and Hanging Rock. The properties along the creek are primarily residential and agricultural and have been inundated by the flood of 1942, 1972 and 1988.

Flood Plain Information, Peters Creek and Lick Run, Roanoke, Virginia, (U.S. Army Corps of Engineers, 1968) addresses flooding along Peters Creek. Peters Creek flows along the western corporate limits of the City of Roanoke and empties into the Roanoke River. Lick Run flows parallel to Interstate 581 through the downtown and empties into Tinker Creek at the eastern corporate limits. The study addresses only the "rural" portion of Lick Run north of the downtown area. Past floods have occurred at an estimated rate of nearly one every three years.

The Governor of Virginia declares a state of emergency when he believes a disaster has occurred or may be imminent that is severe enough to require state aid to supplement local resources in preventing or alleviating damages, loss, hardship or suffering. Once a local state of emergency has been declared, the Governor may then ask for an emergency declaration, which makes federal resources available for immediate response missions. In the event of a Presidential Disaster Declaration, Virginia Department of Emergency Management (VDEM) is further empowered to coordinate federal agency assets that become available. An emergency declaration preempts generally approved administrative purchasing and procurement procedures to make resources immediately available to rescue, evacuate, shelter, provide essential commodities (i.e., heating fuel, food, etc.) and quell disturbances in affected localities.

There have been seven (7) Presidential Disaster Declarations related to flooding in the region since 1969. All of the declarations impacted multiple localities in the region.

Table 3
Presidential Disaster Declarations for Flooding
August 1969 to June 2003

Locality	Declaration Number	Designation Date	Disaster Description
Alleghany County Botetourt County	274	08/23/1969	Severe storms and flooding
Alleghany County Botetourt County Clifton Forge City of Covington Craig County Roanoke County City of Roanoke City of Salem	755	11/09/1985	Severe storms and flooding
Botetourt County Craig County Roanoke County City of Roanoke City of Salem	944	05/19/1992	Severe storms and flooding
Alleghany County Botetourt County Craig County Roanoke County City of Roanoke	1014	03/10/1994	Severe ice storms, flooding
Roanoke County City of Roanoke	1059	07/31/1995	Severe storms and flooding
Alleghany County Botetourt County Clifton Forge City of Covington	1098	02/02/1996	Flooding, high winds, and wind driven rain
Craig County Roanoke County City of Roanoke City of Salem	1458	04/28/2003	Severe winter storm, record/near record snowfall, heavy rain, flooding, and mudslide

Source: Virginia Department of Emergency Management, 2003.

There have been six (6) State Emergency Declarations for flooding in the Region since 1985.

Table 4
State Emergency Declarations for Flooding
1985 to February 2003

Type of Disaster	Localities Affected	Declaration Date	Type	Description	Noted Damage
Flash Flooding, Landslides	Entire State		Continuing Declaration	Executive Order 65 (85)	
Flash Flooding, Landslides	Entire State		Continuing Declaration	Executive Order 15 (86)	
Flooding	Roanoke River Basin	9/18/87	Declaration of State of Emergency	Unusually heavy rains	
Flash Flooding	Western Virginia	4/24/92	Declaration of State of Emergency	Heavy rains occurred in southwest Virginia and continued up the Roanoke Valley and then to the Shenandoah Valley and other affected parts of the state, at least one life was lost, National Guard was called out	Roads and bridges washed out, also considerabl e public and private property damage
Storm	Entire State	6/23/93	Declaration of State of Emergency	Summer storm system crossed the Commonwealth with hail, high winds, and torrential rains, the City of Lynchburg, City of Bedford, Appomattox County and Campbell County were particularly affected	Trees down, massive power outages, farms damaged - crops, farmland and fences
Flash Flooding, Landslides, Dam Failure	Western, Central, Northern, South central Virginia	6/23/95 with extension of area on 6/26/95	Declaration of State of Emergency	Heavy rains resulted in flash floods, mudslides and dam failure in the western and central portions of the state, later other portions of the state, northern and south central) were added, the Virginia National Guard was called out	Dam failure

Note: All disaster declarations in Virginia are Executive Orders issued by the Governor. Disasters without a description in the Virginia Department of Emergency Management file are described by Executive Order number only.
Source: Virginia Department of Emergency Management, 2003.

Hurricanes

A hurricane is a tropical storm with winds that have reached a constant speed of 74 miles per hour or more. Hurricane winds blow in a large spiral around a relative calm center known as the "eye." The "eye" is generally 20 to 30 miles wide, and the storm may extend outward 400 miles. As a hurricane approaches, the skies will begin to darken and winds will grow in strength. As a hurricane nears land, it can bring torrential rains, high winds, and storm surges. A single hurricane can last for more than two weeks over open waters and can run a path across the entire length of the eastern seaboard. August and September are peak months during the hurricane season that lasts from June 1 through November 30.

Some of the greatest rainfall amounts associated with tropical systems occur from weaker Tropical Storms that have a slow forward speed (one to 10 mph) or stall over an area. Due to the amount of rainfall a Tropical Storm can produce, they are capable of causing as much damage as a Category 2 hurricane.

Widespread rainfall of six to 12 inches or more is common during landfall, frequently producing deadly and destructive floods. Such floods have been the primary cause for tropical cyclone-related fatalities over the past 30 years. The risk from flooding depends on a number of factors: the speed of the storm, its interactions with other weather systems, the terrain it encounters, and ground saturation.

Large amounts of rain can occur more than 100 miles inland where flash floods are typically the major threat along with mudslides in mountainous regions. Tornadoes and high winds generally become less of a threat the farther inland a hurricane moves (although there have been several exceptions), but the heavy rains frequently continue and even intensify as the dying, but still powerful, hurricane is forced up higher terrain or merges with other storm systems in the area. For example, Hurricane Camille (1969) devastated the Gulf Coast, but weakened quickly as it moved northeast. The storm combined with a cold front in the mountains of central Virginia to produce an unexpected 30 inches of rain. As a result, 109 people died.

The Saffir-Simpson Hurricane Damage Scale is used to classify hurricanes into five categories from a weak hurricane, Category 1 to a catastrophic hurricane, Category 5. It is believed that scientifically, the strongest possible hurricane that could hit the Virginia Coast is a Category 4 storm. It is believed that the water temperatures off the coast are too cool to support a category five storm. Looking at the Virginia history, a Category 3 storm is without question a strong possibility.

Table 5
Saffir-Simpson Hurricane Damage Scale

Hurricane Category	Sustained Winds (mph)	Damage Potential
1	74 - 95	Minimal
2	96 - 110	Moderate
3	111 - 130	Extensive
4	131 - 155	Extreme
5	> 155	Catastrophic

Source: NOAA, Hurricane Basics, http://www.nws.noaa.gov/oh/hurricane, 2002.

Review of Past Events and Reports

Virginia has been struck by four hurricanes from 1900 to 1996 according to records from the National Hurricane Center. These include two Category 1 hurricanes, one Category 2 and one Category 3.

August 12-16, 1928: Two tropical storms moved across the Florida panhandle and then turned northeast and moved up the Appalachians weakening into depressions. The depressions passed over Virginia just four days apart bringing heavy rain, flash flooding and significant rises on the larger rivers. Major flooding occurred on the Roanoke River through Roanoke and Brookneal. The river crested on the 16th at 18.1 ft (8 ft above flood stage) in Roanoke. It was the fourth highest crest to date on the Roanoke River at Brookneal with 37.2 ft (about 14 ft over flood stage) occurring on the August 12.

October 18, 1932: Tropical storm made landfall on the Gulf Coast moved northeast weakening to a depression. The center passed over the Virginia-Kentucky border into West Virginia. Heavy rains to the east of the storm impacted the Appalachians. It caused major flooding on the Roanoke River through Alta Vista where it crested at 29 feet (11 feet over flood stage) and moderate flooding in South Boston on the Dan River.

August 19, 1939: Hurricane made landfall on the Florida coast and then again on the Gulf Coast. The storm turned northeast and moved up across Virginia as a tropical depression on the 19th. The storm produced heavy rains and flash flooding particularly along the eastern slopes of the southern Blue Ridge. Major flooding occurred on the Roanoke River through Alta Vista (11.5 feet over flood stage).

October 15, 1954, Hurricane Hazel: Hazel maintained hurricane force winds up the East Coast and produced a number of record wind gusts. Lynchburg, Roanoke, and Danville recorded five to six inches of rain causing flooding of small streams.

August 17, 1955, Hurricane Diane: Just 5 days after Connie, along came Diane. Diane made landfall near Wilmington, NC as a Category 1 storm on August 17 and moved north across central Virginia. As she did so, rain spread north up to 250 miles ahead of the storm's eye. On the evening of the 17th, the Blue Ridge saw rainfall amounts of five to 10 inches along the southern and eastern slopes. The Skyline Drive area was hardest hit. The combination of rain from Connie and Diane brought record total rainfall for the month of August. Severe flooding followed on the Rappahannock River with some flooding also on the James, Potomac and Shenandoah Rivers. Norfolk winds gusted to 53 mph from the east, Cape Henry had 43 mph winds with gusts to 49 mph. Roanoke saw winds gusts to 62 mph and Lynchburg 56 mph out of the north.

August 20, 1969, Hurricane Camille: Camille made landfall as a Category 5 hurricane smashing the Mississippi Coast with 200 mph winds on August 17. Camille was the strongest hurricane to make landfall on the U.S. this century. The hurricane maintained force for 10 hours as it moved 150 miles inland. The storm tracked northward weakening and becoming less defined. It moved toward Virginia on the 19th and was only a tropical depression. Moisture from the warm Gulf Stream waters moved northwest toward the storm and new feeder bands formed. These thunderstorms "trained" (one followed the other), into the Blue Ridge south of Charlottesville. In just 12 hours, up to 31 inches of rain fell with devastating results. The ensuing flash flood and mudslide is estimated to have killed 153 people (not all the bodies were found). Most died in Nelson County. The County also saw 113 bridges washed out. All communications were cut off. Major flooding followed as the bulge of water moved down the James River into Richmond. Waynesboro on the South River saw eight feet of water in its downtown and Buena Vista had five and one-half feet in its business section. Damage was estimated at 113 million dollars (1969 dollars).

September 18, 2003, Hurricane Isabel. Hurricane Isabel struck the North Carolina coast at midday and moved north-northeast through the evening hours and following day. Hurricane Isabel's 29 hours of tropical storm force winds carved a wide swath of damage and left behind major flooding across the commonwealth. More than 619 homes reported destroyed and 5,353 with major damage. Sixty-nine jurisdictions have major power outages affecting approximately 1.4 million customers. Twenty-five jurisdictions are experiencing major problems with water and sewage pump stations. Widespread power outages affected 1.9 million customers throughout the Commonwealth. State and local road clearance operations have opened many primary roads, however, 38 remain closed as well as 753 secondary roads. Confirmed fatalities as a result of the storm and its aftermath were 23. The Roanoke Valley-Alleghany area received rain amounts varying from 0.5 to 5.5 inches and 50 mph winds causing light damage.

Figure 3

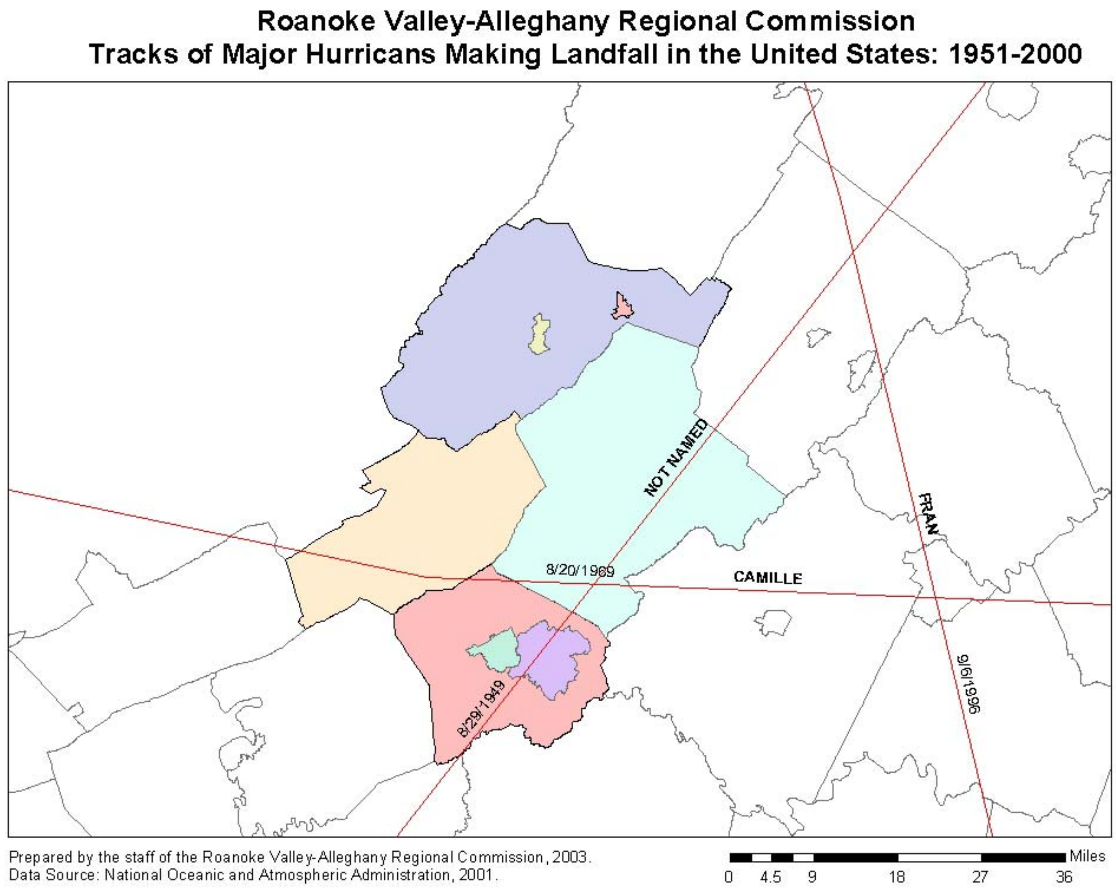


Table 6
Presidential Disaster Declarations for Hurricanes
June 1972 to June 2003

Locality	Declaration Number	Designation Date	Disaster Description
Alleghany County Botetourt County Clifton Forge City of Covington Craig County Roanoke County City of Salem	339	06/29/1972	Tropical storm Agnes
Alleghany County Botetourt County Roanoke County	1135	09/16/1996	Hurricane Fran and associated severe storm conditions

Source: Virginia Department of Emergency Management, 2003.

Table 7
State Emergency Declarations for Hurricanes
1987 to February 2003

Type of Disaster	Localities Affected	Declaration Date	Type	Description	Noted Damage
Hurricane	Entire State	9/22/89	Declaration of State of Emergency	Hurricane Hugo, on September 21, 1989 Hugo made landfall on the Carolinas and was expected to cause heavy rains and high winds in Virginia, much of Virginia's ground had been saturated in recent weeks, flooding was expected, the Virginia National Guard was called out	Anticipation of event
Hurricane	Entire State	8/15/95	Declaration of State of Emergency	Hurricane Felix, predictions that this storm could cause storm surge, heavy rains, flooding, high winds and tornadoes should the storm make landfall in the cities and counties east of I-95, inland areas could also be impacted, the Virginia National Guard was called out	
Hurricane	Entire State	7/11/96	Declaration of State of Emergency	Hurricane Bertha, predictions of storm surge, heavy rains, flooding and high winds in localities east of I-95, inland areas could also be impacted, the Virginia National Guard was called out	
Hurricane	Entire State	9/6/96	Declaration of State of Emergency	Hurricane Fran, predictions of heavy rains that could cause flash and riverine flooding, predicted landfall is between North and South Carolina, the Virginia National Guard was called out	
Hurricane	Entire State	8/25/98	Declaration of State of Emergency	Hurricane Bonnie, predictions of storm surge, heavy rains and high winds, predicted landfall south of the Virginia coast in North Carolina, the Virginia National Guard was called out	
Hurricane	Entire State	9/14/99	Declaration of State of Emergency	Hurricane Floyd, predictions of storm surge, heavy rains, high winds and tornadoes, predicted storm track takes Floyd over south central and northeastern Virginia during the next 72 hours resulting in the potential for significant rainfall causing river flooding and high wind damage, the Virginia National Guard was called out	

Note: All disaster declarations in Virginia are Executive Orders issued by the Governor. Disasters without a description in the Virginia Department of Emergency Management file are described by Executive Order number only.
Source: Virginia Department of Emergency Management, 2003.

References:

Inland Flooding, National Weather Service, http://www.nws.noaa.gov/oh/hurricane/inland_flooding.html, 2001.

Hurricane Basics, NOAA, http://www.nws.noaa.gov/oh/hurricane, 2002.

StormReady, National Weather Service, http://www.nws.noaa.gov/stormready.

Virginia Hurricanes, National Weather Service, http://165.176.249.147/library/vahurr/va-hurr.htm.

U.S. Mainland Hurricane Strikes by State, 1900-1996, National Hurricane Center, http:/www.nhc.noaa.gov/paststate.html.

Hurricane Isabel Situation Reports #1 through #7, Virginia Emergency Operations Center, 2003.

Preliminary Local Storm Report, September 19, 2003, National Weather Service Blacksburg, Virginia, 2003.

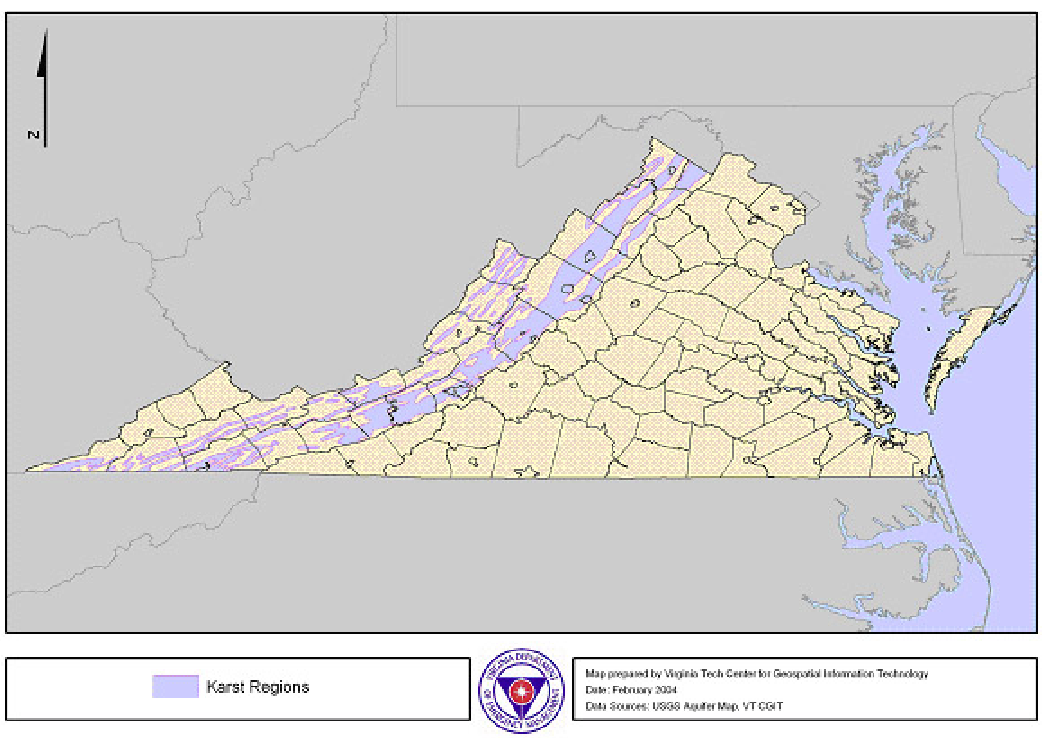
Karst

Karst is defined as a landscape with sinkholes, springs, and streams that sink into subsurface caverns. In karst areas, the fractured limestone rock formations have been dissolved by flowing groundwater to form cavities, pipes, and conduits. Sinkholes, caves, sinking streams, and springs signal the presence of underground drainage systems in karst areas.

Sinkholes are natural depressions on the land surface that are shaped like a bowl or cone. They are common in regions of *karst*, where mildly acidic groundwater has dissolved rock such as limestone, dolostone, marble, or gypsum. Sinkholes are subsidence or collapse features that form at points of local instability. Their presence indicates that additional sinkholes may develop in the future.

The area of karst in Virginia, as shown in Figure 4, are primarily limited to the mountainous regions of the state. Because land subsidence caused by karst is very site-specific and often occurs in undeveloped areas, there is no existing long-term record for Virginia. USGS advises that the original map was produced at a scale of 1:7,500,000; this coverage is not as accurate, and should be used for broad-scale purposes only.

Figure 4
Karst Regions in Virginia



Landslide

The term "landslide" describes many types of downhill earth movements, ranging from rapidly moving catastrophic rock avalanches and debris flows in mountainous regions to more slowly moving earth slides and other ground failures.

Though most landslide losses in the United States accrue from many widely distributed events, landslides can be triggered by severe storms and earthquakes, causing spectacular damage in a short time over a wide area. Some landslides move slowly and cause gradual damage, whereas others move so rapidly that they can destroy property and take lives. Debris flows are a common type of fast-moving landslide that generally occurs during intense rainfall on saturated soil. Their consistency ranges from watery mud to thick, rocky mud (like wet cement) which is dense enough to carry boulders, trees, and cars. Debris flows from many different sources can combine in channels, where their destructive power may be greatly increased. (Debris Flow Hazards in the Blue Ridge of Virginia, USGS Fact Sheet 159-96P. L. Gori and W. C. Burton, 1996).

Landslides can be triggered by both natural changes in the environment and human activities. Inherent weaknesses in the rock or soil often combine with one or more triggering events, such as heavy rain, snowmelt, and changes in groundwater level, or seismic or volcanic activity. Erosion may remove the toe and lateral slope support of potential landslides. Human activities triggering landslides are usually associated with construction and changes in slope and surface water and groundwater levels. Changes in irrigation, runoff and drainage can increase erosion and change groundwater levels and ground saturation.

Review of Past Events and Reports

Historical records tell us that destructive landslides and debris flows in the Appalachian Mountains occur when unusually heavy rain from hurricanes and intense storms soaks the ground, reducing the ability of steep slopes to resist the downslope pull of gravity. For example, during Hurricane Camille in 1969, such conditions generated debris flows in Nelson County, Virginia, 90 miles south of Madison County. The storm caused 150 deaths, mostly attributed to debris flows, and more than $100 million in property damage. Likewise, 72 hours of storms in Virginia and West Virginia during early November 1985 caused debris flows and flooding in the Potomac and Cheat River basins that were responsible for 70 deaths and $1.3 billion in damage to homes, businesses, roads, and farmlands.

Most localities of the RVARC region have experienced small localized landslide events, especially areas in the valleys. The mountain slopes are characterized by the USGS as having a high susceptibility but a low incidence, indicating that few events have occurred on the higher slopes. The only documented concentration of landslides has been along Smith Creek in the Town of Clifton Forge. A State Emergency Declaration was issued in November of 1987 for the area. Heavy rains caused landslides along Smith Creek in Clifton Forge, the third occurrence in the past decade. The area is landslide prone and structures are at risk from further landslides. A study is warranted to determine scope of the problem and a method to stabilize the area.

There has been only one Presidential Disaster Declaration related to landslides in the region. The declaration impacted multiple localities in the region. There have been three (3) State Emergency Declarations for landslides in the Region since 1987.

Table 8
Presidential Disaster Declarations for Landslides
1965 to June 2003

Locality	Declaration Number	Designation Date	Disaster Description
Craig County Roanoke County City of Roanoke	1458	04/28/2003	Severe winter storm, record/near record snowfall, heavy rain, flooding, and mudslide

Source: Virginia Department of Emergency Management, 2003.

Table 9
State Emergency Declarations for Landslides
1987 to February 2003

Type of Disaster	Localities Affected	Declaration Date	Type	Description	Noted Damage
Landslides	Town of Clifton Forge	11/30/87	Declaration of State of Emergency	Heavy rains caused landslides along Smith Creek in Clifton Forge, third occurrence in the past decade, area is landslide prone and structures are at risk from further landslides, study is warranted to determine scope of the problem and stabilize the area	Property damage, residences at risk
Flash Flooding, Landslides, Dam Failure	Western, Central, Northern, South central Virginia	6/23/95 with extension of area on 6/26/95	Declaration of State of Emergency	Heavy rains resulted in flash floods, mudslides and dam failure in the western and central portions of the state, later other portions of the state, (northern and south central) were added, the Virginia National Guard was called out	Dam failure
Winter Emergency, Landslide	Entire State	2/11/94	Declaration of State of Emergency	Severe winter storm across the Commonwealth, large accumulations of ice, sleet and snow and moderate rain throughout the state, the southwestern portion of the state had heavy rains, mudslides and flooding occurred, 28 localities opened shelters, Virginia National Guard called out	More than 235,000 homes had no power, trees were down and some roads were blocked by mudslides

Note: All disaster declarations in Virginia are Executive Orders issued by the Governor. Disasters without a description in the Virginia Department of Emergency Management file are described by Executive Order number only.
Source: Virginia Department of Emergency Management, 2003.

References:

National Landslide Hazards Mitigation Strategy: A Framework For Loss Reduction, USGS Open-File Report 00-450, E. C. Spiker And P. L. Gori, 2000.

Debris Flow Hazards in the Blue Ridge of Virginia, USGS Fact Sheet 159-96P. L. Gori and W. C. Burton, 1996.

Tornado

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. It is spawned by a thunderstorm (or sometimes as a result of a hurricane) and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. The damage from a tornado is a result of the high wind velocity and wind-blown debris. Tornado season is generally March through August, although tornadoes can occur at any time of year. They tend to occur in the afternoons and evenings: over 80 percent of all tornadoes strike between noon and midnight.

Table 10
Fujita - Pearson Tornado Scale

Category F0:	Gale tornado (40-72 mph); light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
Category F1:	Moderate tornado (73-112 mph); moderate damage. The lower limit is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads.
Category F2:	Significant tornado (113-157 mph); considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
Category F3:	Severe tornado (158-206 mph); Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.
Category F4:	Devastating tornado (207-260 mph); Devastating damage. Well-constructed houses leveled; structure with weak foundation blown off some distance; cars thrown and large missiles generated.
Category F5:	Incredible tornado (261-318 mph); Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile sized missiles fly through the air in excess of 100 yards; trees debarked; incredible phenomena will occur.

Source: Tornado Facts, NOAA, http://www.outlook.noaa.gov/tornadoes/tornfact.htm

Review of Past Events and Reports

April 24, 1896: Around 4:30 pm, a tornado moved northeast from Salem into Roanoke destroying a bowling alley and several other buildings. A framed home near the bowling alley was leveled, killing three of the eight-member family in the house. The five others were injured.

May 2, 1929, "Virginia's Deadliest Tornado Outbreak": It has been said that tornadoes do not occur in mountainous areas. This is false. In Bath and Alleghany counties, the Cowpasture Valley is at an elevation of 1,500 feet and lies between two ridges that rise 1,000 feet above the valley. On May 2, 1929 a tornado struck around 6 pm. Property losses in the communities of Coronation and Sitlington were great. At least 10 people were injured, but none were killed. There were five tornadoes reported on that day. More may have struck remote areas. Twenty-two people were killed and over 150 injured with at least a half a million dollars in damages.

April 4, 1974, "Super Outbreak": It was before sunrise when the severe thunderstorms rolled into southwest Virginia. The storms were part of a squall line ahead of a cold front, and they had a history of being deadly. It was the worst tornado outbreak in U.S. history. April 3-4, 1974 is known as the "*Super Outbreak*" with 148 tornadoes, 315 people killed and 5,484 injured. It was the most tornadoes ever in recorded in a 24-hour period and it was the worst tornado outbreak since February 19, 1884. In Virginia, eight tornadoes hit. One person was killed and 15 injured, all in mobile homes. Over 200 homes and barns and over 40 mobile homes and trailers were damaged or destroyed. Saltville area and Roanoke were the hardest hit. An F3 tornado touched down on the west edge of Roanoke, near Salem around 5 a.m., and moved through the north part of Roanoke to Bonsack and into Botetourt County to the Blue Ridge area. The path was initially a mile wide, but it continued to narrow to 75 yards across near the end of its track of damage. It hit four schools (two lost portions of their roof and two had windows broken out) and two apartment complexes, Grandview Village Apartments (18 buildings damaged) and Ferncliff Apartments (lost roof). The Red Cross reported 120 homes damaged or destroyed in the Roanoke area. Trees were down on buildings and cars. Carports, garages, and porches were flattened. Roofs were partly blown off several houses in Botetourt.

August 5, 2003: A small tornado struck northern Roanoke County. The storm had winds of 110-113 miles per hour and caused damage to ITT Industries and Sunnybrook Garage on Plantation Road in addition to damaging roofs, fences and a car in the area. No injuries were reported as a result of the tornado.

There have not been any Presidential Disaster Declarations or State Emergency Declarations related to tornados in the Region.

References:

Tornados, NOAA, http://www.outlook.noaa.gov/tornadoes.

Tornado Facts, NOAA, http://www.outlook.noaa.gov/tornadoes/tornfact.htm

Virginia Tornados, B. M. Watson, NOAA, http://www.vdem.state.va.us/library/vatorn/va-tors.htm, 2002.

National Weather Radio, National Weather Service, http://www.nws.noaa.gov/nwr.

Wildfire

Wildfires are a natural part of the ecosystem in the Roanoke Valley and Alleghany Highlands. However, wildfires can present a substantial hazard to life and property. In the Roanoke Valley, wildfires are second only to flooding as the greatest recurring natural hazard. In 1999, Fort Lewis Mountain in the western part of Roanoke County burned out of control for a week, destroying land and endangering homes before it was brought under control. Other fires have occurred on Brushy Mountain, Poor Mountain, Twelve O'Clock Knob, Yellow Mountain, and even portions of Mill Mountain that lies within the heart of the City of Roanoke.

Review of Past Events and Reports

According to the Virginia Department of Forestry, Virginia experiences forest fire seasons in the spring and fall. The spring fire season begins in mid February and extends through April. The fall fire season usually covers a period of a few weeks in late October to mid November. In 1999 the spring fire season extended into the summer months. One of the region's largest fires occurred on August 7, 1999. The Purgatory Mountain Fire in Botetourt County burned 1,285 acres and cost over $166,000 to contain.

A five-year *average* for the total number of wildfires, total acres burned, and average size of fire was calculated by local governments and the Virginia Department of Forestry. In Alleghany County, the total number of wildfires is 40; average annual total acres burned is 337; and average size fire is 8.44 acres. In Botetourt County, the total number of wildfires is 49; the average annual total acres burned is 1,437; and the average size fire is 29.33 acres. In Craig County, the total number of wildfires is 25; the average annual total acres burned is 359; and the average size fire is 14.36 acres. In Roanoke County the total number of wildfires is 35; the total annual average acres burned is 360.7; and the average size fire is 10.3 acres.

There have not been any Presidential Disaster Declarations related to wildfire in the region. There have been three (3) State Emergency Declarations for wildfire in the Region since 1995.

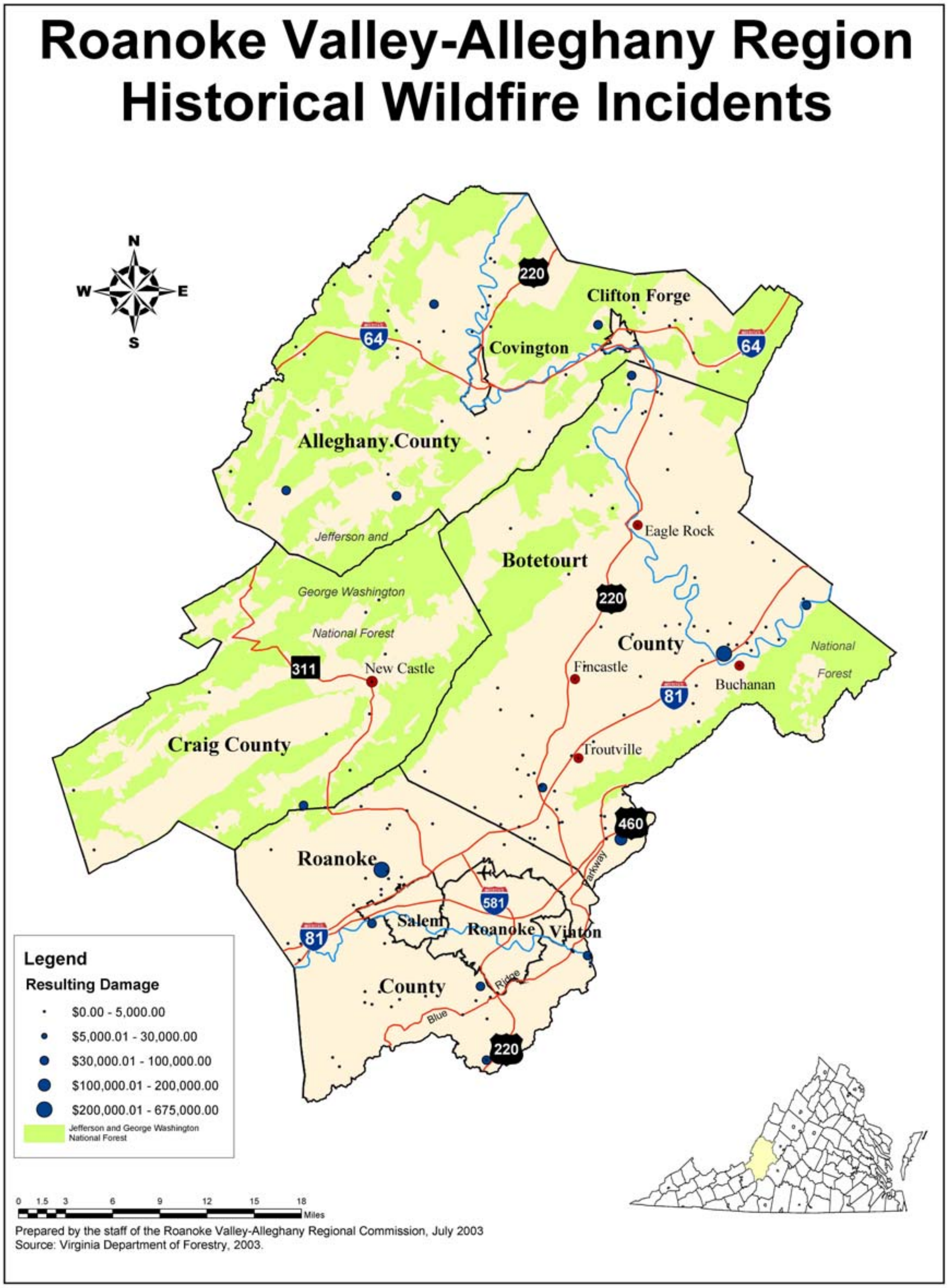
A regional map (Figure 5) of past wildfire incidences is provided on page 36. Locality specific wildfire incidence maps are provided in Appendix C.

Table 11
State Emergency Declarations for Wildfires
1987 to February 2003

Type of Disaster	Localities Affected	Declaration Date	Type	Description	Noted Damage
Forest Fires	Entire State	4/9/95	Declaration of State of Emergency	Due to extreme dry conditions in the Commonwealth has forest fires in existence and other potential for forest fires, the Virginia National Guard was called out	
Forest Fires, Plant Disease Risk, Insect Infestation	Entire State	9/6/96	Declaration of State of Emergency	Amendment to EO 66 (96), due to damage done to the Commonwealth by Hurricane Fran there was a risk of forest fires, spread of plant diseases and undesirable insect increase	Large number of trees down
Forest Fires, Drought	Entire State	10/26/01	Declaration of State of Emergency	Existence of drought conditions caused a greater potential for forest fires, the Virginia National Guard was called out, a statewide ban on open burning was announced	

Note: All disaster declarations in Virginia are Executive Orders issued by the Governor. Disasters without a description in the Virginia Department of Emergency Management file are described by Executive Order number only.
Source: Virginia Department of Emergency Management, 2003.

Figure 5
Historical Wildfire Incidents



Winter Storms

Virginia's biggest winter storms are the great "Nor'easters". At times, nor'easters have become so strong that they have been labeled the "White Hurricane". In order for these storms to form, several things need to occur. High pressure builds over New England. Arctic air flows south from the high center into Virginia. The colder and drier the air is, the denser and heavier it becomes. This cold, dry air is unable to move west over the Appalachian Mountains. Instead, it remains trapped to the east side, funneling down the valleys and along the coastal plain toward North Carolina. To the east of the arctic air is the warm water of the Gulf Stream. The contrast of cold air sinking into the Carolinas and the warm air sitting over the Gulf Stream creates a breeding ground for storms. Combine this with the right meteorological conditions such as the position of the jet stream, and storm development may become "explosive" (sudden, rapid intensification; dramatic drop in the central pressure of the storm).

The impact of winter storms on the region's localities can be seen from the General Inventory maps in Appendix C.

Review of Past Events and Reports

The region's greatest snowfall totals have occurred in January, February, and March. In January of 1966, the area received a total of 41.2 inches of snow. February of 1960 found the area blanketed with 27.6 inches and March delivered 30.3 inches that same year.

The second greatest official snow accumulation in a single 24-hour period occurred on February 11th and 12th of 1983 when 18.6 inches covered the region. The storm resulted in snowdrifts of up to three feet in height. This was the third heaviest snowfall in over 100 years.

The "Storm of the Century" hit the valley in March 1993. With blizzard-like conditions and nearly 30 inches of snow, this was the biggest winter storm in 10 years. Localities in the region received a Presidential Declaration of Emergency and the National Guard was mobilized to help with emergency transportation needs. Shelters were open for those without electricity.

A devastating storm struck the region and surrounding jurisdictions in February 1994, with one to three inches of solid ice from freezing rain and sleet. Roads were blocked, electric and phone lines were lost and a large portion of the valley was without electricity.

The "Blizzard of '96" dropped 22.2 inches officially in 24 hours in early January of 1996 that is the current record 24-hour snowfall. Many areas of the region received more than 36 inches during the same period.

There have been five (5) Presidential Disaster Declarations related to winter storms in the region. The declarations impacted multiple localities in the region. There have been eleven (11) State Emergency Declarations for winter storms in the Region since 1993.

Table 12
Presidential Disaster Declarations for Winter Storms
1965 to June 2003

Locality	Declaration Number	Designation Date	Disaster Description
Alleghany County Botetourt County Craig County Roanoke County City of Roanoke	1014	03/10/1994	Severe ice storms, flooding
Craig County Roanoke County	1021	04/11/1994	Severe winter ice storm
Alleghany County Botetourt County Clifton Forge City of Covington Craig County Roanoke County City of Roanoke City of Salem	1086	02/02/1996	Blizzard of 96 (severe snow storm)
Alleghany County Botetourt County Craig County Roanoke County	1318	02/28/2000	Severe winter storms
Craig County Roanoke County City of Roanoke City of Salem	1458	04/28/2003	Severe winter storm, record/near record snowfall, heavy rain, flooding, and mudslide

Source: Virginia Department of Emergency Management, 2003.

Table 13
State Emergency Declarations for Winter Storms
1987 to February 2003

Type of Disaster	Localities Affected	Declaration Date	Type	Description	Noted Damage
Winter Emergency	Entire State	3/12/93	Declaration of State of Emergency	Extremely low temperatures and heavy snowfall accompanied by high velocity winds, sleet and freezing rain fell over the Commonwealth, hundreds of motorist were stranded, thousands of people were without power or heat, shelters were opened, Virginia National Guard was called out	Public and private property
Winter Emergency	Western Virginia	1/3/94	Declaration of State of Emergency	An unusually severe winter storm was expected to impact the western portion of Virginia shortly after January 3, 1994, the conditions did not materialize although two feet of snow had been predicted, the Virginia National Guard was called out	
Winter Emergency	Entire State	1/19/94	Declaration of State of Emergency	Due to severe winter weather (extremely low temperatures, heavy snowfall, high winds, sleet and freezing rains) winter fuel was being used faster than homes and agribusiness could be supplied, exemptions were granted to haulers delivering heating fuels	Poultry and livestock were affected
Winter Emergency, Landslide	Entire State	2/11/94	Declaration of State of Emergency	Severe winter storm across the Commonwealth, large accumulations of ice, sleet and snow and moderate rain throughout the state, the southwestern portion of the state had heavy rains, mudslides and flooding occurred, 28 localities opened shelters, Virginia National Guard was called out	More than 235,000 homes had no power, trees were down and some roads were blocked by mudslides

(continues)

Winter Emergency	Entire State	3/2/94	Declaration of State of Emergency	Severe winter weather buried the Commonwealth with snow to depths of 1 and one-half to two feet of snow, drifts occurred in the Shenandoah Valley and Northern Virginia due to 25 mile per hour winds, ice condition existed on the roads and torrential rains caused flooding in the coastal and western regions of the state, the ground was saturated by previous winter storms and this exacerbated the storm's effects, Virginia National Guard was called out	
Winter Emergency	Entire State	1/6/96	Declaration of State of Emergency	Predicted winter storm with blizzard conditions, snowfall of 12-24 inches expected throughout the Commonwealth	
Winter Emergency	Entire State	2/2/96	Declaration of State of Emergency	A storm system moved through Virginia February 1-4, 1996, an Arctic air mass from Canada moved across the state, it had the potential to cause widespread power outages, and fuel and other resource shortages, it had the potential to cause severe economic losses including the agricultural community and livestock operations, the Virginia National Guard was called out	
Winter Emergency	Entire State	1/28/98	Declaration of State of Emergency	Severe winter storm causing heavy snowfall in the western section of the state causing riverine flooding, coastal flooding and high winds on the coast, the Virginia National Guard, EO was extended for second storm predicted shortly after	
Winter Emergency	Entire State	1/25/00	Declaration of State of Emergency	Winter storm with high winds dumped up to 18 inches of snow across much of the state, there were drifting and blizzard conditions, the Virginia National Guard was called out, the EO was extended to cover a predicted storm on January 28-31, 2000	

(continues)

Winter Emergency	Entire State	12/11/02	Declaration of State of Emergency	Icy conditions caused massive power outage	
Winter Emergency	Entire State	2/17/03	Declaration of State of Emergency	Northwest Virginia received significant snow, the storm caused icy conditions, impassable roads and flooding in the state, SW Virginia received more than 4 inches of rain that caused flooding and mudslides	

Note: All disaster declarations in Virginia are Executive Orders issued by the Governor. Disasters without a description in the Virginia Department of Emergency Management file are described by Executive Order number only.
Source: Virginia Department of Emergency Management, 2003.

References:

Hazard Analysis, Project Impact Roanoke Valley, (no date).

StormReady, National Weather Service, http://www.stormready.noaa.gov/, 2003.

(BLANK)

Chapter 3

Vulnerability Assessment

The vulnerability assessment of the region's localities to specific hazards is based on a combination of the probability, extent and past occurrences of hazard events. Probability is based on the number of past documented occurrences of a hazard. A higher number of occurrences resulted in the disaster being given a higher ranking. Extent is based on the hazards area of impact- either localized or jurisdiction wide. Hazards with a wider area of impact were given a higher ranking. Past occurrences is based on whether or not a specific hazard has occurred in a locality. Disasters that have actually occurred in a locality were given a higher ranking.

Table 14
Natural Hazard
Probability of Occurrence

Locality	Earthquake	Flood	Hurricane	Landslide	Tornado	Wildfire	Winter Storm
Alleghany County	M	M	L	M	L	M	M
Botetourt County	M	M	L	M	L	M	M
Town of Buchanan	M	H	L	M	L	L	M
Town of Clifton Forge	M	H	L	M	L	L	M
City of Covington	M	H	L	M	L	L	M
Craig County	M	L	L	M	L	M	M
Town of Fincastle	M	L	L	M	L	L	M
Town of Iron Gate	M	L	L	M	L	L	M
Town of New Castle	M	L	L	M	L	L	M
City of Roanoke	M	H	L	M	L	L	M
Roanoke County	M	H	L	M	L	M	M
City of Salem	M	H	L	M	L	L	M
Town of Troutville	M	L	L	M	L	L	M
Town of Vinton	M	M	L	M	L	L	M

Probability
H – High Probability based on past number of occurrences.
M – Medium Probability based on past number of occurrences.
L – Low Probability based on past number of occurrences.

Table 15
Natural Hazard
Extent of Disaster

Locality	Earthquake	Flood	Hurricane	Landslide	Tornado	Wildfire	Winter Storm
Alleghany County	L	L	J	L	L	L	J
Botetourt County	L	L	J	L	L	L	J
Town of Buchanan	L	L	J	L	L	L	J
Town of Clifton Forge	L	L	J	L	L	L	J
City of Covington	L	L	J	L	L	L	J
Craig County	L	L	J	L	L	L	J
Town of Fincastle	L	L	J	L	L	L	J
Town of Iron Gate	L	L	J	L	L	L	J
Town of New Castle	L	L	J	L	L	L	J
City of Roanoke	L	L	J	L	L	L	J
Roanoke County	L	L	J	L	L	L	J
City of Salem	L	L	J	L	L	L	J
Town of Troutville	L	L	J	L	L	L	J
Town of Vinton	L	L	J	L	L	L	J

Extent
L – Localized Area
J – Jurisdiction-wide

Table 16
Natural Hazard
Past Occurrences of Disaster

Locality	Earthquake	Flood	Hurricane	Landslide	Tornado	Wildfire	Winter Storm
Alleghany County	N	Y	Y	N	Y	Y	Y
Botetourt County	N	Y	Y	Y	Y	Y	Y
Town of Buchanan	N	Y	Y	N	N	N	Y
Town of Clifton Forge	N	Y	Y	Y	Y	N	Y
City of Covington	N	Y	Y	N	N	N	Y
Craig County	N	Y	Y	Y	N	Y	Y
Town of Fincastle	N	N	Y	N	N	N	Y
Town of Iron Gate	N	Y	Y	N	N	N	Y
Town of New Castle	N	Y	Y	N	N	N	Y
City of Roanoke	N	Y	Y	N	Y	N	Y
Roanoke County	N	Y	Y	Y	Y	Y	Y
City of Salem	N	Y	Y	N	Y	N	Y
Town of Troutville	N	Y	Y	N	N	N	Y
Town of Vinton	N	Y	Y	N	N	N	Y

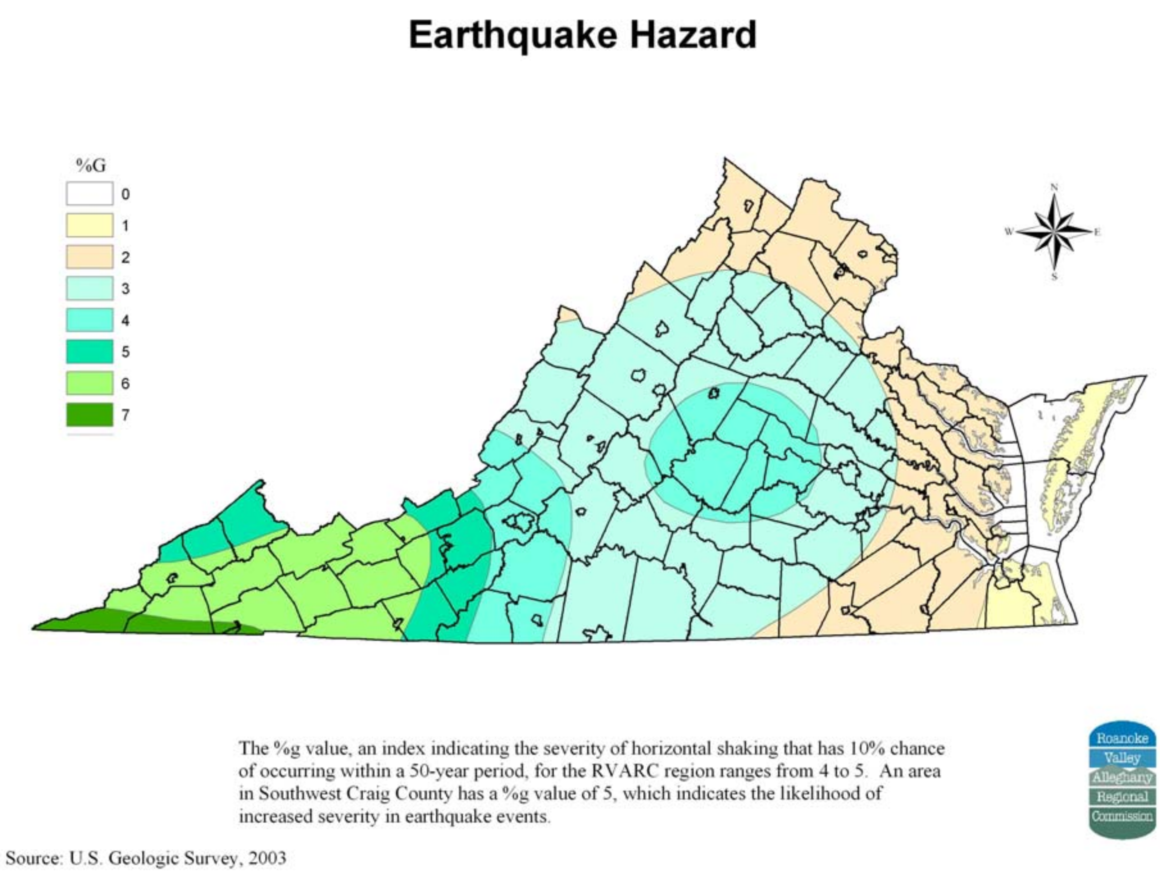
Past Occurrences
Y - Yes
N – No

Based on past probability, extent and past occurrences, the Pre-Disaster Planning Committee selected the following disasters for inclusion in this Plan: earthquakes, flooding, hurricanes, landslides, tornados, wildfires, and winter storms.

Earthquake

The map below illustrates the severity of horizontal shaking that has a 10% probability of occurring within a 50-year period for the Commonwealth of Virginia. The *%g* value, an index indicating the severity of horizontal shaking that has a 10% chance of occurring within a 50-year period, for the Roanoke Valley-Alleghany region ranges from 4 to 5. An area in southwest Craig County has a %g value of 5, which indicates the likelihood of increased severity in earthquake events. *Overall, earthquake events in the region will most likely be minor or, at most, moderate events with little or no structural damage.*

Figure 6
Earthquake Hazard



Flood

The disaster hazard most likely to affect the citizens of the Roanoke Valley is widespread flooding or isolated flash flooding. The Roanoke Valley has historically proven susceptible to flooding. The main contributing factor to sustained flooding and flash flooding is the intensity of the rainfall and its duration. The mountains surrounding the alley make the region prone to runoff from heavy rain. Much of this rainfall is absorbed into the ground, replenishing groundwater. Pavement, concrete, and buildings limit the amount of ground cover available for the absorption of water. Water runoff in urbanized areas is increased two to six times over what would occur in natural terrain. The result is swollen streams overflowing their banks and ending with dangerous widespread flooding of the Roanoke Valley.

National Flood Insurance Program

Many localities participate in, and are in good standing with, the National Flood Insurance Program (NFIP) by enforcing floodplain management regulations that meet federal requirements. This program allows property owners to purchase flood insurance from NFIP.

Many residents have purchased flood insurance to help recover from flood losses. Flood insurance covers only the improved land or the actual building structure. Although it is helpful to those who have suffered losses, it may also provide a false sense of security and discourage people and businesses from relocating to a more appropriate site. Many residents that experience flood loss rebuild in the same location, only to be flooded again. These repetitive loss properties expose lives and property to flood hazards. FEMA and local governments recognize this problem and attempt to remove repetitive loss properties through land acquisition, home relocation or by elevating the structure. Continued repetitive loss claims lead to increased damage by floods, higher insurance rates, and increasing amounts of tax dollars being spent on disaster relief.

Table 17
National Flood Insurance Program Communities

Community Name	Date of Entry	Current Effective Map
Alleghany County	07/16/87	02/19/92
Botetourt County	06/15/78	06/15/78
Buchanan, Town of	11/02/77	11/02/77
Clifton Forge, Town of	09/01/78	09/01/78
Covington, City of	01/03/79	01/03/79
Craig County	02/02/90	02/02/90
Fincastle, Town of	05/15/78	05/15/78
Iron Gate, Town of	01/16/87	01/16/87
New Castle, Town of	02/22/90	02/02/90
Roanoke County	10/17/78	10/18/95
Roanoke, City of	11/04/81	10/18/95
Salem, City of	09/02/81	10/18/95
Troutville, Town of	10/14/77	10/14/77
Vinton, Town of	03/15/78	10/18/95

Source: FEMA, Federal Insurance Administration, 2001.

Table 18
NFIP Policy Statistics

Community Name	Policies In Force	Insurance In Force	Written Premium In Force
Alleghany County	144	$133,307	$65,444
Botetourt County	154	$179,896	$84,997
Buchanan, Town of	38	$28,979	$25,917
Clifton Forge, Town of	15	$9,840	$7,674
Covington, City of	132	$88,006	$52,899
Craig County	50	$32,899	$34,071
Fincastle, Town of	4	$3,475	$1,195
Iron Gate, Town of	4	$11,398	$3,053
New Castle, Town of	5	$4,597	$1,561
Roanoke County	336	$363,150	$191,875
Roanoke, City of	607	$919,215	$595,057
Salem, City of	468	$650,565	$374,666
Troutville, Town of	10	$6,438	$4,643
Vinton, Town of	48	$103,106	$75,302
RVARC Region	2015	$2,534,871	$1,518,354
Virginia	76,472	$104,487,065	$29,492,416

Source: FEMA, National Flood Insurance Program, 2003.
Note: Policies In Force – Policies in force on the "as of" date of the report, 12/31/2000.
Insurance In Force – The coverage amount for policies in force.
Written Premium In Force – The premium paid for policies in force.

Table 19
NFIP Claims
1978-2001

Community Name	Total Losses	Closed Losses	Open Losses	CWOP Losses	Total Payments
Alleghany County	161	140	0	21	$1,987,616.48
Botetourt County	174	154	0	20	$1,980,616.48
Clifton Forge, Town of	7	7	0	0	$44,239.52
Covington, City of	137	122	0	15	$823,107.58
Craig County	55	36	0	19	$397,364.50
Roanoke County	311	249	0	62	$2,564,993.76
Roanoke, City of	792	644	0	148	$12,850,011.78
Salem, City of	449	369	0	80	$8,316,201.62
Vinton, Town of	71	54	0	17	$1,166,598.98
RVARC	2157	1775	0	382	$30,130,750.70
Virginia	15100	10880	22	4198	$141,191,186.10

Source: FEMA, National Flood Insurance Program, 2003.
Note: Total losses – All losses submitted regardless of the status; Closed losses – Losses that have been paid. Open losses – Losses that have not been paid in full; CWOP losses – Losses that have been closed without payment; Total Payments - Total amount paid on losses.

Riverine Flooding

Roanoke Valley Communities

In 1997, the Roanoke Valley Regional Stormwater Management Plan was prepared by Dewberry & Davis under contract to the Fifth Planning District Commission (now the Roanoke Valley-Alleghany Regional Commission). Localities participating in this study include only the Cities of Roanoke and Salem, the County of Roanoke and the Town of Vinton. The project is funded by the City of Roanoke, the City of Salem, the County of Roanoke, the Town of Vinton, and a stormwater mitigation grant from the Federal Emergency Management Agency (FEMA).

The overall focus of the Regional Stormwater Management Plan is the implementation of policies and procedures for mitigation of floods in the Roanoke Valley. The plan focused on 16 major watersheds. To accomplish this task, the report includes components that are designed to assist jurisdictions in making decisions about stormwater management and related flooding.

Following hydraulic (HEC-2) and hydrologic (HEC-1) analysis of the 16 watersheds, development of flood profiles and floodplains, flood hazards in the study area were identified. Residential structures located in the floodplains were identified and a determination was made as to the cause of the flooding.

Possible solutions to reduce or eliminate flooding at residential structures were screened to determine those that would reduce the severity of the flooding. Roads that were inundated by storms with a 10-year or more frequent recurrence interval were also identified.

The following section describes the 16 watersheds and vulnerability to flooding identified in the Roanoke Valley Regional Stormwater Management Plan.

Back Creek

Located in Southeast Roanoke County, the Back Creek watershed encompasses a 58.7 square mile drainage basin that originates in the Blue Ridge Mountains on Poor Mountain at an elevation of 3,600 feet above sea level. It flows in a northeasterly direction for about 25 miles until it joins the Roanoke River near the borders of Roanoke, Bedford, and Franklin Counties.

Flooding problems along Back Creek (running west to east through southern Roanoke County), Martins Creek (southwest Roanoke County along Rt. 696), Little Back Creek (southwest Roanoke County along Rt. 695 and Rt. 221) and Back Creek Tributaries A & B (southern Roanoke County) were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

On Back Creek, flooding is scattered throughout the length of the stream. Two areas that experience house flooding are between Merriman Road (southern Roanoke County along Rt. 613) and Coleman Road (Rt. 735) and between Cotton Hill Road (Rt. 688) and Old Mill Road (Rt. 752) in southern Roanoke County. The tributaries to Back Creek also experience scattered house flooding.

The Roanoke Valley Regional Stormwater Management Plan estimated that 165 houses in the watershed would be flooded by a 100-year storm event.

Barnhardt Creek

With an origin on Poor Mountain at 2,700 feet above sea level in southwestern Roanoke County, the Barnhardt Creek watershed is a 4.2 square mile drainage basin located in south central Roanoke County, southern Salem, and the southwestern portion of the City of Roanoke.

Flooding problems along Barnhardt Creek for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 30 homes along Barnhardt Creek including more than 20 that are inundated by a 10-year storm. One of the major flooding problems on Barnhardt Creek is upstream of Cravens Creek Road (located in the westernmost part of Roanoke City at the boarder with the City of Salem). Another is upstream of Electric Road - State Route 419 in the Farmingdale subdivision (located between Rt. 685 and Rt. 419 at the junction of Roanoke County, the City of Salem and City of Roanoke) along Lakemont Drive. The Meadow Creek subdivision located in southwest Roanoke County, also experiences house flooding both upstream and downstream of Meadow Creek Drive (off of Rt. 686).

The Roanoke Valley Regional Stormwater Management Plan estimated that 36 houses in the watershed would be flooded by a 100-year storm event

Butt Hollow Creek

Located wholly within central Roanoke County and the western portion of the City of Salem, Butt Hollow Creek watershed is a 2.7 square mile fan-shaped drainage basin. Butt Hollow Creek originates on Fort Lewis Mountain at an elevation of 3,260 feet above sea level. It flows southeasterly for about three miles to its confluence with the Roanoke River.

Flooding problems along Butt Hollow Creek for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 30 homes along Butt Hollow Creek including more than 10 that are also inundated by a 10-year storm. The major flooding problems on Butt Hollow Creek are at Routes 11/460 and Butt Hollow Road (Rt. 640) at the western corporate limits of the City of Salem.

The Roanoke Valley Regional Stormwater Management Plan estimated that 29 houses in the watershed would be flooded by a 100-year storm event.

Carvin Creek

The Carvin Creek watershed originates on Tinker Mountain in southeastern Botetourt County at an elevation of 3,200 feet above sea level. It flows in a northeasterly direction for about 3 miles to the Carvin Cove Reservoir, which is a public drinking water supply for the City of Roanoke. Located in northeast Roanoke County, northern City of Roanoke, and the western portion of Botetourt County, the Carvin Creek watershed is a 28 square mile fan-shaped drainage basin.

Flooding problems along Carvin Creek, West Fork Carvin Creek, and Deer Branch, for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. Problems with debris blockage were also identified.

The major flooding problem in the Carvin Creek watershed is in the Sun Valley subdivision located on the main stem of Carvin Creek (Verndale Drive and Rt. 623 in northeastern Roanoke County). Approximately 100 houses are located in the 100-year floodplain including more than 25 that are inundated by a 10-year storm. Another problem in the Carvin Creek watershed is in the Summerdean subdivision in northeastern Roanoke County south of Rt. 11 where debris blockage problems at Plantation Road and Peyton Street increase the flood elevations enough to inundate several more houses. The major flooding problem on West Fork Carvin Creek is in the Captains Grove subdivision in Roanoke County (near the intersection of Rt. 623 and Rt. 11 / 220, just east of the Roanoke Regional Airport) where seven houses are located in the 100-year floodplain. On Deer Branch in northern Roanoke County near the intersection of Peters Creek Road and Williamson Road (Rt. 11), the worst flooding problem is on U.S. Route 11 just upstream of the confluence of Deer Branch with West Fork Carvin Creek. At this location U.S. Route 11 is flooded by the 2-year storm for approximately 1,000 feet of the road.

The Roanoke Valley Regional Stormwater Management Plan estimated that 160 houses in the watershed would be flooded by a 100-year storm event.

Cole Hollow Brook

From 3,020 feet above sea level on Fort Lewis Mountain, Cole Hollow Brook flows southwesterly and then southeasterly for about 4 miles until its confluence with the Roanoke River in Salem. The Cole Hollow Brook watershed is a 5.9 square mile drainage basin. This oblong watershed is located primarily in Roanoke County (paralleling Rt. 618), but the southern portion is in the City of Salem at Rt. 618 and Rt. 11.

Flooding problems along Cole Hollow Brook for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 45 buildings/homes in west Salem along Cole Hollow Brook including more than 10 that are inundated by a 10-year storm. One of the major flooding problems on Cole Hollow Brook is upstream of West Main Street in the City of Salem at Horner Lane. Another is downstream of Interstate 81 in the Mitchell subdivision in west Salem along Windsor Avenue.

The Roanoke Valley Regional Stormwater Management Plan estimated that 43 houses in the watershed would be flooded by a 100-year storm event.

Dry Branch

Lying within Roanoke County and the City of Salem, the Dry Branch watershed is a 4.5 square mile drainage basin located primarily in north central Roanoke County that parallels Rt. 619 and 733. The southern portion of the watershed is in northern Salem. With a width of about two miles near its center, the watershed is fan shaped and has a length of 4.5 miles.

Flooding problems along Dry Branch for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. The major flooding problems on are in the Hockman Subdivision at Dry Branch's crossing of East Main Street (Rt. 11) and Burwell Street and at the Cameron Court subdivision at Dry Branch's crossing of Carrollton Avenue in Salem.

The Roanoke Valley Regional Stormwater Management Plan estimated that 149 houses in the watershed would be flooded by a 100-year storm event.

Gish Branch

Originating on Fort Lewis Mountain in north Roanoke County, the Gish Branch watershed descends from 3,080 feet above sea level. It flows in a southeasterly direction for about 3.5 miles until its confluence with Mason Creek in the City of Salem. Gish Branch lays wholly within north central Roanoke County and the north central portion of the City of Salem.

Flooding problems along Gish Branch for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

The existing conditions 100-year storm floods about 11 homes along Gish Branch on North Mill Road (Rt. 631) including more than 8 that are inundated by a 10-year storm. One of the major flooding problems on Gish Branch is upstream of Kessler Mill Road (Rt. 630) in east Salem where several homes and a commercial building are inundated by a 10-year storm.

The Roanoke Valley Regional Stormwater Management Plan estimated that 12 houses in the watershed would be flooded by a 100-year storm event.

Glade Creek

The Glade Creek watershed is a 33 square mile drainage basin located in northeast Roanoke County, northeast City of Roanoke, and northwest Vinton with the northern portion of the watershed located in Botetourt County. Glade Creek originates in the Blue Ridge Mountains near Curry Gap at an elevation of 2,500 feet above sea level. It flows in a southwesterly direction for about 11 miles to its confluence with Tinker Creek at the border of the City of Roanoke and Vinton.

Flooding problems for both existing and developed land use conditions along Glade Creek, Cook Creek, and Glade Creek Tributaries A and B, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. Problems with debris blockage were also identified.

The major flooding problem on Glade Creek is in the Town of Vinton upstream of the confluence of Glade Creek with Tinker Creek. From just upstream of Gus W. Nicks Boulevard to the confluence there are approximately 100 houses in the developed conditions (Year 2020) 100-year floodplain and 50 of which are inundated by the 10-year storm in the Town of Vinton. The May 1985, Feasibility Study by Camp Dresser and McKee states that the intersection of Walnut Avenue and Fifth Street located near the confluence of Glade Creek with Tinker Creek is the most severe flooding problem in the Town of Vinton.

The Roanoke Valley Regional Stormwater Management Plan estimated that 122 houses in the watershed would be flooded by a 100-year storm event.

Lick Run

The Lick Run watershed is located primarily in north central City of Roanoke with the northern portion in north central Roanoke County. It is a 7.8 square mile drainage basin that is narrow and has a maximum width of about two miles near its mouth. It is approximately 5.5 miles long. Lick Run originates at the interchange of Interstate 81 and Route 11 at an elevation of approximately 1,200 feet above sea level. Lick Run flows in a southeasterly direction for about 7.5 miles until its confluence with Tinker Creek immediately north of Norfolk Avenue and the Norfolk Southern Railyard.

Much of the central business district of Roanoke is subject to flooding by Lick Run. The Williamson Road area has exhibited some of the most severe and continuing local flooding problems in the City of Roanoke. Areas upstream of Washington Park (Lick Run north of Orange Avenue) have also been subject to flooding. High water marks along Lick Run were used by the consultants to verify the computed flood elevations

Flooding problems along Lick Run and Trout Run, for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. Problems with debris blockage were also identified.

The major flooding problem in the Lick Run watershed is overland flooding of residential neighborhoods (10^{th} Street, Norris Drive and Andrews Road) and the central business district along Lick Run and Trout Run in the City of Roanoke where both streams are contained underground in the storm sewer system for the City of Roanoke.

The Roanoke Valley Regional Stormwater Management Plan estimated that 207 houses in the watershed would be flooded by a 100-year storm event.

Mason Creek

Originating at an elevation of 3,260 feet above sea level on Fort Lewis Mountain in northern Roanoke County near Big Bear Rock Gap, the Mason Creek watershed is a 29.6 square mile drainage basin. It includes the Gish Branch watershed and is located in north central Roanoke County, eastern Salem, and western City of Roanoke. The watershed is fan-shaped and has a length of about 8.5 miles and a maximum width of 9 miles near its headwaters. From Fort Lewis Mountain, Mason Creek flows northeasterly for about seven miles to Mason Cove where it turns and flows southeasterly 7.5 miles to its confluence with the Roanoke River in the City of Salem.

Flooding problems along Mason Creek and Jumping Run Creek, for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. Problems with debris blockage were also identified.

In the downstream portion of Mason Creek, the major flooding problems are at two trailer parks, the Salem Village Trailer Park (south of the intersection of Rt. 460 and Kessler Mill Road in Salem) and a trailer park located along Schrader Street in eastern Salem, south of the Salem Turnpike (Rt. 460). These trailer parks are subject to flooding in the 2-year storm. Another major problem in the Mason Creek watershed is in the vicinity of East Main Street where several buildings and houses are inundated by a 10-year storm including the Lakeside Plaza Shopping Center. Other areas subject to flooding include North Electric Road to Janee Drive (north of Interstate 81), Janee Drive to Carvins Cove Road , Carvins Cove Road to Catawba Valley Road, and Catawba Valley Road to Plunkett Road (all sections parallel Mason Creek and Kessler Mill Road from the City of Salem and then north along Catawba Road, Rt. 311, into Roanoke County).

The Roanoke Valley Regional Stormwater Management Plan estimated that 519 houses in the watershed would be flooded by a 100-year storm event.

Mud Lick Creek

Mudlick Creek watershed is a 9.6 square mile drainage basin. It is located in east central Roanoke County and southeast City of Roanoke. The watershed is fan shaped with a length of about 4.5 miles and a maximum width of 3.5 miles near its headwaters. Mudlick Creek flows northeasterly for about 4.5 miles until its confluence with the Roanoke River in Roanoke.

Flooding problems along Mudlick Creek for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval. Buildings located in the floodplain were identified as well as overtopped roads.

There are several areas of house flooding on Mudlick Creek which are scattered along the stream. The major flooding areas on Mudlick Creek are located downstream of Brandon Avenue in the western part of Roanoke City, downstream of Grandin Road (Rt. 11) in the Westhampton/Rosalind Hills subdivisions (Brandon Avenue and Langdon Road in Roanoke City) and along South Park Circle in the Southwoods subdivision (northwest of the intersection of Garst Mill Road and Halevan Road in Roanoke County). There are approximately 60 houses in the 100-year floodplain of Mudlick Creek of which 40 are also inundated by the 10-year storm.

The Roanoke Valley Regional Stormwater Management Plan estimated that 60 houses in the watershed would be flooded by a 100-year storm event.

Murray Run

The Murray Run watershed lies wholly within Roanoke County and the City of Roanoke. It is an oblong shaped watershed consisting of a 2.9 square mile drainage basin located in south central Roanoke County and southeast City of Roanoke. Originating from nearly 1,400 feet above sea level just south of Roanoke and north of Starkey Road, Murray Run flows northeasterly for about four miles to its confluence with the Roanoke River in Roanoke.

Flooding problems along Murray Run for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads.

One of the major flooding problems on Murray Run is upstream of Brandon Avenue in the City of Roanoke along Ross Lane where 17 houses are in the 100-year floodplain including 13 that are inundated by a 10-year storm. Another is located both upstream and downstream of West Road in the Lakewood subdivision in the City of Roanoke where 12 houses are in the 100-year floodplain including 10 that are inundated by a 10-year storm. Several of the Pebble Creek Apartments (Circle Brook Drive in Roanoke County) located upstream of Ogden Road are also located in the 10 and 100-year floodplain. Upstream of Crawford Road near its intersection with Janney Lane in the Green Valley subdivision in Roanoke County, five houses are flooded by a 100-year storm and four of these are also flooded by a 10-year storm.

The Roanoke Valley Regional Stormwater Management Plan estimated that 52 houses in the watershed would be flooded by a 100-year storm event.

Ore Branch

With an origin near Chestnut Ridge south of Roanoke, the Ore Branch watershed begins at an elevation of almost 1,700 feet above sea level. From Chestnut Ridge, it flows northeasterly for about 2.5 miles along Route 220 in Roanoke County and Franklin Road in the City of Roanoke to its confluence with the Roanoke River at Wiley Drive in the City of Roanoke.

Flooding problems along Ore Branch for both existing and developed land use conditions, were identified for flood events ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. The major flooding problem in the Ore Branch watershed is downstream of the Cycle Systems recycling yard near the confluence of Ore Branch with the Roanoke River at Wonju Street and Franklin Road in the City of Roanoke. This area is heavily developed with commercial and industrial buildings.

The Roanoke Valley Regional Stormwater Management Plan estimated that 62 houses in the watershed would be flooded by a 100-year storm event.

Peters Creek

The Peters Creek watershed originates at an elevation of 2,380 feet above sea level on Brushy Mountain in Roanoke County. This nine square mile drainage basin is located in central Roanoke County, northwest

City of Roanoke, and northeast Salem. The watershed has a length of about six miles and a maximum width of two miles near the center. From Brushy Mountain, it flows southeasterly for about six miles to its confluence with the Roanoke River in Roanoke.

Flooding problems along Peters Creek and Peters Creek Tributaries A, B and C were identified for flood events. ranging from the 2-year recurrence interval to the 100-year recurrence interval storms. Buildings located in the floodplain were identified as well as overtopped roads. The major flooding problem in the Peters Creek watershed are upstream of Westside Boulevard (near Rolling Hill Avenue), downstream of Westside Boulevard (Laurel Ridge Apartments at Westside and Shenandoah Avenue), upstream of Melrose Avenue (intersection of Melrose and Peters Creek Road in the City of Roanoke) and in the vicinity of Northwood Drive (including Bermuda Road and Laura Road) in the City of Roanoke. All of the Peters Creek watershed streams have adjacent scattered buildings and residences subject to flooding. Several specific areas for concern within the Peters Creek watershed in the City of Roanoke are: Westside Boulevard to Shenandoah Avenue, Shenandoah Avenue to Salem Turnpike in the Washington Heights region, Salem Turnpike to Melrose Avenue, Melrose Avenue to Peters Creek Road, Peters Creek Road to Shenandoah Bible College Access Road, Shenandoah Bible College Access Road to Peach Tree Drive, Peach Tree Drive to Northwood Drive, and Northwood Drive to Green Ridge Road.

The Roanoke Valley Regional Stormwater Management Plan estimated that 214 houses in the watershed would be flooded by a 100-year storm event.

Tinker Creek

Located in northeast Roanoke County, northeast City of Roanoke, northwest Vinton, and southeast Botetourt County, the Tinker Creek watershed is a 112 square mile drainage basin. Tinker Creek watershed originates at an elevation of 2,400 feet above sea level on Tinker Mountain near in Botetourt County, Virginia. It flows in a southerly direction about 11 miles until its confluence with the Roanoke River at the border between the City of Roanoke and Vinton.

Along Tinker Creek, the major flooding problem is located upstream of Dale Avenue (Rt. 24/364) near the confluence of Glade Creek on the boarder of the City of Roanoke and Town of Vinton. A substantial number of houses and buildings lie within the Tinker Creek floodplain. Some areas of specific concern in the City of Roanoke are: Mouth of Tinker Creek to Dale Avenue, Dale Avenue to Wise Avenue, Wise Avenue to Orange Avenue, Orange Avenue to 13th Street, 13th Street to Old Mountain Road, Old

Mountain Road to Preston Avenue, Preston Avenue to the City limit. Areas of specific concern in the County of Roanoke are: the Roanoke City limit to Hollins Road, Hollins Road to Clearwater Avenue, Clearwater Avenue to Ardmore Avenue, and Ardmore Avenue to Williamson Road (at this point Tinker Creek is in Botetourt County and outside of the Stormwater Study).

The Roanoke Valley Regional Stormwater Management Plan estimated that 134 houses in the watershed would be flooded by a 100-year storm event.

Wolf Creek

Originating in the Blue Ridge Mountains at Stewart Knob at an elevation above sea level of 2,435 feet, the Wolf Creek watershed is a 4.9 square mile drainage basin. It is located in eastern Roanoke County and east Vinton. The watershed flows in a southeasterly direction for about 4 miles until its confluence with the Roanoke River in Vinton.

No significant areas of flooding were identified on Wolf Creek. Presently, the main risk associated with Wolf Creek is the overtopping of roadways by floodwaters. Three roadways are identified: Niagara Road is subject to 5-year storms, and Hardy Road and Mountain View Road are overtopped by 10-year storms. Flooding of these roadways prevents access to some residential areas.

The Roanoke Valley Regional Stormwater Management Plan estimated that there would not be any houses in the watershed flooded by a 100-year storm event.

The remaining localities in the Roanoke Valley-Alleghany Region have not performed studies as detailed as that of the Roanoke Valley Regional Stormwater Management Plan. For these areas, past studies performed by the USGS, FEMA and HUD were used in combination with GIS and FIRMs to document vulnerability to flooding.

Alleghany Highlands Communities

Potentially, the main flooding problem in Alleghany County is along the Jackson River. Gathright Dam is the only flood protection structure in the County. Since the completion of the dam, there has been widespread belief that flooding should not occur. This belief helps lead to increased pressure for development along the floodplain of the Jackson River. Although the reduction in flood stages provided by the dam is substantial, it will not completely eliminate the flood hazards downstream of Potts Creek and Dunlap Creek. Gathright Dam only controls approximately 38 percent of the Jackson River watershed, and has no control over the watersheds of Potts and Dunlap Creeks.

The USGS has recorded stages of area streams. Records of river stages and discharges on the Jackson River at Falling Spring gage, located approximately 10 miles upstream from Covington, have been maintained since April 1925. To supplement the Falling Springs records, data is recorded from the USGS gaging stations at Dunlap Creek and Potts Creek. The Dunlap gage, located 4.3 miles above its confluence with the Jackson River, has been recording data since October 1928. Records of river stages and discharges on Potts Creek, 7.5 miles upstream of its mouth, have been maintained from October 1928 to September 1956, and October 1965 to present. There is also a USGS stream gage on the Cowpasture River.

In 1986, the Federal Emergency Management Agency (FEMA) completed a Flood Insurance Study for Alleghany County. In 1992, the study was updated and provided detailed data on Wilson Creek and its tributaries. The floodplains along the Jackson River are areas of intensive development and should be noted as possible hazardous areas.

The U.S. Department of Housing and Urban Development (HUD), Federal Insurance Administration (FIA), 1978 Flood Insurance Study of Clifton Forge, Virginia, provides details on the effects of flooding along the Jackson River and Smith Creek. Flooding on the smaller streams Hazel Run, Dry Creek, and East Branch were studied by approximate methods. The Jackson River flows easterly through the town with a relatively well-defined channel and banks covered with vegetation and trees. CSX Railroad parallels the river along its length in town. The steep banks of the river prevent development on the flood plain. Smith Creek flows in a southerly direction from its headwaters in Bath County, through Clifton Forge to the Jackson River. Development, consisting primarily of residences, public buildings and businesses is concentrated along both sides of the stream throughout its entire reach.

Floods have occurred and can be expected to occur on the Jackson River and Smith Creek in Clifton Forge during all seasons of the year. During all major floods, high velocity flood flows and hazardous conditions would exist in the main stream channel and in some parts of the flood plain. Intense rainfall from local thunderstorms or by tropical disturbances will most likely be the source of the more severe floods on the Jackson. Flooding at the mouth of Smith Creek can be caused by rainfall runoff from the watershed or by backwater from the Jackson when it floods.

Damage from past floods along the Jackson River has been minor due to the topography and physical characteristics of the floodplain. However this is not true on Smith Creek. At a number of locations, the floodplain is severely restricted by buildings that have been constructed on opposite sides of the stream. Near the center of town, flow is confined for a distance of approximately 400 feet by a maze of culverts of varying sizes and capacities. Due to the numerous buildings that have been constructed over this section of the creek, potential for serious flood losses exists. If the culvert system becomes clogged, floodwaters would travel over the streets and a large portion of the business district would be flooded.

The US Department of Housing and Urban Development and Federal Insurance Administration 1978 Flood Insurance Study of the City of Covington, Virginia details the effects of fluvial flooding from the Jackson River. Mill Branch, Harmons Run, and Dry Run Branch by approximate methods. The study does take into consideration the storage effects of Gathright Dam. The Jackson River flood plain contains a mixture of residential and commercial development with some light industry located in the area. The flood plains of the tributaries of the Jackson contain a majority of residential development with occasional commercial development. The Jackson River flows in a southerly direction through the City of Covington with a well-defined bank covered with vegetation and trees. Dry Branch flows in a northwesterly direction to the Jackson. Floods have occurred and can be expected to occur on the Jackson River in Covington during all seasons of the year. During all major floods, high velocity flood flows and hazardous conditions would exist in the main stream channel and in some parts of the flood plain.

Botetourt County Communities

The Flood Insurance Study, Town of Buchanan, Virginia, performed by the US Department of Housing and Urban Development and Federal Insurance Administration in 1977 documented the impact of the James River and Purgatory Creek on the Town of Buchanan. Purgatory Creek that flows into the James River within the corporate limits of Buchanan and forms the eastern town limit. Most of the residential and business areas of the town are above the flood plain. However, there are many residential, commercial, and industrial properties subject to flooding, many of which have been damaged by flooding in the past. The CSX Railroad parallels the James River on the south bank and the Norfolk Southern Railroad parallels the north bank throughout the Buchanan study area. During the 100-year flood portions of both tracks would be flooded according to the Flood Insurance Study. The high school, the sewage treatment plant, several businesses, and many homes would be flooded by the 100-year flood. US Highway 11 crosses the James River at Buchanan. While the bridge does not produce backwater, the approaches to the structure would be flooded.

The 1988 Reconnaissance Report, James River, Buchanan, Virginia, Section 205 Flood Control Study, by the US Army Corps of Engineers provides information about potential flooding along Looney, Purgatory and Bearwallow Creeks. Entering the James River from the west of Buchanan is Looney Creek. Bearwallow Creek flows into the James just east of town. Purgatory Creek flows east into the James at the eastern corporate limits of Buchanan. The Study did not predict flood losses. The Section 205 Flood Control Study prepared and reviewed two alternatives for reducing flood loss in Buchanan: a 600-year levee and a 100-year levee. Due to the cost involved and low benefits of the alternatives, the Corps of Engineers determined that further study of developing local flood control measures was not appropriate at the time.

The 1989 Reconnaissance Report, James River, Eagle Rock, Virginia, Section 205 Flood Control Study, by the US Army Corps of Engineers, study area included the entire community of Eagle Rock and its immediate vicinity just downstream from the confluence of Craig Creek with the James River. The study estimates that the damages for a 100-year flood would be $605,000 (1989 dollars). Field reconnaissance performed for the Reconnaissance Report indicated that there would be a minimal amount of commercial and residential flooding below the 100-year event. This would be limited to the old mill, railroad station, and railways. Due to the cost involved and low benefits of the alternatives, the Corps determined that further study of developing local flood control measures for the community of Eagle Rock was not appropriate at the time.

Flood Prone Roadways

A flood prone roadway is defined as any public road that has a history of being covered by enough water in a manner that the road surface, markings and edges are not visible to the operator of a motor vehicle, cyclists or pedestrians. Such conditions could be caused by stream/river flooding, poor drainage along roadways or normal surface runoff. Water on the roadway could be either standing or moving, and could also leave debris such as gravel, leaves and branches on the roadway.

About 40 percent of flood related deaths occur to people traveling in motor vehicles. Suddenly changing water depths, water currents and road damage make crossing a flooded roadway very dangerous for both motor vehicles and pedestrians. Rural areas are particularly vulnerable because roads are lightly traveled and often not closed to traffic as quickly as urban roadways.

The Rural Flood Prone Roadway Study by the Fifth Planning District Commission (1999) documented flood prone roadways in the rural portion of the region with the assistance of VDOT, the National Weather Service, and local officials. These roads are described in the following section.

Alleghany County *(VDOT and local sources)*

A. SR 600 (Indian Draft Road) at the I-64 bridge.
B. SR 600 (Indian Draft Road) at Humpback Bridge.
C. SR 634 (Riverland Road) along the Cowpasture River below Sharon School.
D. SR 629 (Douthat Road) just before the Buckhorn Store.
E. SR 616 (Rich Patch Road) just below Rich Patch Union Church near the intersection of Routes 616 and 621 (Roaring Run Road).
F. SR 623 (White Rock Gap Road) about two miles from SR 616 (Rich Patch Road) at the creek intersection just beyond Bryant Farm.

Botetourt County *(VDOT and local sources)*

A. Route 674 (Tinker Mill Road) has a low water bridge near the old mill. When water floods about 12 homes are cut off from road access. Six to ten hours of closure is typical. A possible solution indicated by VDOT would be to replace bridge with box culvert; however, the closeness to the mill would be a problem.

B. Tinker Creek floods SR 674 (Tinker Mill Road) in the Daleville area .5 miles west of US 220.
C. Catawba Creek floods the intersection of SR 600 (Breckinridge Mill Road) and 665 (Haymakertown Road).
D. Back Creek floods SR 640 (Lithia Road), and its minor tributaries flood SR 643 (Mountain Valley Road), 644 (Ellis Run Lane), 645 (Fringer Trail), and 689 (Pulaski Mine Road) in the Spec, Lithia, and Pico areas.
E. Craig Creek floods SR 615 (Craig Creek Road) in several spots from the James River to Roaring Run. Also floods SR 685 (Craig Creek Ball Park Road) on the opposite side of Craig Creek, and SR 683 (Patterson Trail) to US 220.
F. Catawba Creek floods SR 600 (Breckinridge Road) two miles west of Fincastle.
G. Crush Run floods SR 681 (Poor Farm Road) between SR 679 (Peck Lane) and SR 630 (Springwood Road) just northeast of Fincastle.
H. Little Patterson Creek floods SR 684 (Sugar Tree Hollow Road), which parallels the creek.
I. Lapsley Creek floods SR 726 (Lapsley Run Road) from the James River, to the intersection with SR 687 (Elburnell Drive).
J. Craig Creek floods SR 615 (Craig Creek Road) in three locations, just west of Oriskany, near Silent Dell, and at Roaring Run.
K. Little Patterson Creek & Patterson Creek floods SR 819 (Barger Drive) where they join.
L. An unnamed creek floods SR 610 (Plank Road) near I-81 in the extreme northeast portion of the county.
M. A small creek off Purgatory Mountain floods SR 649 (Lake Catherine Drive) four miles northwest of Buchanan.
N. Jennings Creek floods SR 614 (Jennings Creek Road) from Arcadia to the dead end. Also, minor tributaries of Jennings Creek flood SR 618 (McFalls Creek Road) and SR 620 (Middle Creek Road).

Clifton Forge (Clifton Forge Police Department)

A. Upper end of Commercial Street in an area referred to as “Neddleton Addition.” A small 20’ long bridge crossing Smith Creek will flood during extremely heavy rainfall.

B. A small bridge located just above the 900 block of Rose Street tends to flood during heavy rainfall. This blocks access to SR 606. Water usually subsides in less than one hour. Dry Creek, which runs under the bridge, is fed by runoff from Fore Mountain and Warm Springs Mountain.
C. Rose Street Parking lot is a low lying area bordering Dry Creek.

City of Covington *(VDOT and Covington Police Department)*

A. Dry Run (north Alleghany Avenue, US Route 220 - Hillcrest Drive).
B. Downtown Area (Court Street - Riverside Avenue - Maple Avenue - North Lexington Avenue - North Craig Avenue - Royal Avenue - West Chestnut Street).
C. Sunnymeade Area (Lyman Avenue - Dalton Avenue - Conrad Avenue).
D. West Jackson Street Area.
E. Parrish Court Avenue (Parrish Street - Phillip Street - Gordon Street).
F. Idlewilde Area (South Carpenter Drive - Marshall Street - Trout Street - Michigan Avenue).
G. Rayon View Area (Wood Street - Gilliam Street - Plum Avenue - Gum Avenue).

The effect on the citizens of Covington is usually limited to water damage from the rising water (there is usually little damage from moving water) in residences and businesses. There are several streets and areas which are blocked due to the water, these include North Alleghany Avenue, the Royal Avenue Area, Marshall Street, Trout Street, Michigan Avenue, and parts on the Rayon View Area.

The major effects in the city are residential damage and limited business damage due to the use of property in the areas. The effect on City Emergency Operations could be extremely devastating. The road blockages on North Alleghany Avenue, Michigan Avenue, South Carpenter Drive, and in the flooded area prevent emergency vehicles from entering these areas to deliver services. In the past, the city has stationed fire, police, and rescue vehicles on the south side of the road blockage on South Carpenter Drive because of the distance to the nearest mutual aid department (Boiling Springs Fire and Rescue - 14 miles). Law enforcement vehicles would have to travel in excess 18 miles to reach this area. The areas of the city on Michigan Avenue would be isolated from any city emergency services. The road blockage on North Alleghany Avenue could possibly isolate citizens in the extreme northern end of the city and citizens in Alleghany County from fire and rescue services provided by Covington Fire Department and

Covington Rescue Squad. The Alleghany County Sheriff's office would have to travel in excess of 15 miles to reach areas in the northern end of Alleghany County because of this blockage.

Craig County *(VDOT and local sources)*

A. The intersection of Craig Creek and Broad Run along route 311. This is approximately three miles south of New Castle.
B. Portions of Route 611 along Craig Creek.
C. Sinking Creek floods SR 627 one mile southeast of the town of Simmonsville at a low water bridge. A new bridge could be constructed at a higher elevation. It is blocked three or four times per year.
D. Craig Creek. A small feeder creek (Turnpike Creek) floods SR 651 about five miles southwest of Abbott.
E. Meadow Creek floods SR 623 about 4 miles southwest of New Castle.
F. Broad Run floods SR 618, which parallels the creek, from about 3/4 miles north of Route 311 to four miles north. It is flooded 5-6 times per year. The road would have to be relocated, but no homes are along this road.
G. Craig Creek floods at the intersection with Route 612.
H. Route 614 has a low water bridge that floods 2-3 times per year. A new bridge at a higher elevation is a possible solution.
I. The intersection of Route 681 and Route 614 is blocked 1-2 times per year for 12-18 hours. Camp Easter Seal access is blocked in these situations. Raising the elevation of the road is a possible solution.
J. Route 647 near the end of state maintenance is flooded 1-2 times per year.

Roanoke County *(VDOT and local sources)*

A. Route 688 (Cotton Hill Road) west of the intersection with Route 613 (Merriman Road). Rains in excess of two inches covers roadway for approximately eight hours at a time. Citizens can be stranded at their home due to the erosion of the private entrance culverts in their driveways. Traffic can be blocked by debris that is washed into the road. Stream bank improvements on the parallel creek and driveway culverts are possible solutions indicated by VDOT.
B. Route 607 (Bottom Creek Road), approximately 1.5 miles west of intersection Route 711 (Tinsley Lane). Rains in excess of two inches cause the roadway to cover for approximately 12-

48 hours. Citizens endure a hardship of having to employ alternative routes of travel which may increase their distance up to 10 miles.

C. Route 744 (Rocky Road), approximately 0.10 miles East of intersection Route 607 (Bottom Creek Road). Rains in excess of two inches cause the roadway to cover for approximately 36 hours. Citizens endure a hardship of having to travel alternative routes, which may increase their distance up to 6.5 mi. Construction of a bridge instead of roadway cross pipes may be a solution indicated by VDOT.
D. West Fork of Carvin Creek floods SR 623 (Florist Road) at Brookside near the intersection with Williamson Road.
E. Deer Branch floods SR 836 (Plymouth Street) near Brookside.
F. Carvin Creek floods Palm Valley Road and Verndale Road in the Sun Valley subdivision.
G. Carvin Creek floods SR 743 (John Richardson Road) near where Carvin Creek joins Tinker Creek (near the Hershberger Road and Plantation Road intersection).
H. Glade Creek floods the intersection of SR 636 (Glade Creek Road) and 703 (Pioneer Road)in Bonsack.
I. Upper Carvin Creek (and poor drainage) floods SR 740 (Carvin Creek Road) in several locations from near Bennett Springs, to the reservoir.
J. Back Creek and minor tributaries flood sections of SR 676 (Back Road) between U.S. 220 and SR 615 (Starlight Lane).
K. Tinker Creek floods SR 856 (Summer View Drive) and 601 (Hollins Road), just off U.S. 11 in the Hollins area.
L. West Fork of Carvin Creek floods Loch Haven Road near Loch Haven Country Club, 2 miles east of U.S. 419.
M. Back Creek floods SR 721 (Ferguson Valley Road) where it parallels the creek, and also SR 666 (Bandy Road) at the Middle Back Creek Bridge near the intersection with SR 667 (Old Virginia Springs Road).
N. SR 666 (Bandy Road) also experiences drainage flooding near Bandy Cemetery.
O. West River Road and Poor Mountain Road along the Roanoke River in the Glenvar area of Roanoke County can become flooded.
P. Dutch Oven Road near State Route 311 in the Mason Cove area of Roanoke County can become flooded.

There is little written documentation on flooded roadways in the region, and often the knowledge is distributed among the employees of several state and local organizations. A central and structured reporting and inventory system would provide better documentation on problem areas. By maintaining an inventory of flood prone roadways, officials will have documentation to help evaluate possible solutions to mitigate the impact of flooded roadways in the future. While some flooding from streams and runoff can be expected, standing water in roadways indicates improper drainage that should be remedied if the problem is reoccurring. While the blockage of regular traffic is mostly an inconvenience, emergency service personnel should have easy access to written documentation on flood prone roadways so that they can research alternate routes before emergencies occur. In some heavily affected areas, evacuation plans could be developed for larger flood events.

Dam Safety

There are many types of emergency events that could affect dams. Whenever people live in areas that could be flooded as a result of failure of or operation at a dam, there is a potential for loss of life and damage to property. In April 1977, President Carter issued a memorandum directing the review of federal dam safety activities by an ad hoc panel of recognized experts. In June 1979, the ad hoc interagency committee on dam safety (ICODS) issued its report, which contained the first guidelines for federal agency dam owners. The *Federal Guidelines for Dam Safety* encourage strict safety standards in the practices and procedures employed by federal agencies or required of dam owners regulated by the federal agencies. The guidelines address management practices and procedures but do not attempt to establish technical standards. The general purpose of these guidelines is to encourage thorough and consistent emergency action planning to help save lives and reduce property damage in areas that would be affected by dam failure or operation.

With the passage of the National Dam Safety Program Act of 1996, Public Law 104-303, ICODS and its Subcommittees were reorganized to reflect the objectives and requirements of Public Law 104-303. In 1998, the newly convened Guidelines Development Subcommittee completed work on the update of all of the following guidelines:

- Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners
- Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams
- Federal Guidelines for Dam Safety: Earthquake Analyses and Design of Dams
- Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams
- Federal Guidelines for Dam Safety: Glossary of Terms

Because dam failure can cause severe downstream damage, FEMA requires all dam owners to develop an Emergency Action Plan (EAP) for warning, evacuation, and post-flood actions. The EAP is a formal document that identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The EAP specifies actions the dam owner should take to moderate or alleviate the problems at the dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities of the emergency situation. It also contains inundation maps to show the emergency management authorities of the critical areas for action in case of an emergency.

The effectiveness of EAPs can be enhanced by promoting a uniform format – based on the Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners - which ensures that all aspects of emergency planning are covered in each plan. Uniform EAPs and advance coordination with local and state emergency management officials and organizations should facilitate a timely response to a developing or actual emergency situation.

Organizations and individuals who own or are responsible for the operation and maintenance of dams are encouraged to use these guidelines to develop, update, and/or revise their EAPs. These guidelines supersede the Emergency Action Planning Guidelines for Dams, FEMA 64/February 1985 and incorporate many technologically advanced emergency action planning concepts available from a wide variety of sources.

In addition to Federal regulations, the Commonwealth of Virginia has enacted dam safety regulations and established a Dam Safety Program managed by the Department of Conservation and Recreation. The program's purpose is to provide for safe design, construction, operation and maintenance of dams to protect public safety.

Authority for operation of the program was established in *The Virginia Dam Safety Act*, Article 2, Chapter 6, Title 10.1 (10.1-604 et seq) of the Code of Virginia and *Dam Safety Regulations* enacted by the Virginia Soil and Water Conservation Board (VS&WCB). No person or entity shall construct, begin to construct, alter or begin to alter an impounding structure until the VS&WCB has issued a construction permit.

All dams in Virginia are subject to the Dam Safety Act unless specifically excluded. A dam may be excluded if it:

- is less than 6 feet in height;
- has a capacity less than 50 acre-feet and is less than 25 feet in height;
- has a capacity of less than 15 acre-feet and is more than 25 feet in height;
- is used for primarily agricultural purposes and has a capacity less than 100 acre-feet (should use or ownership change, the dam may be subject to regulation);
- is owned or licensed by the Federal Government; or
- is operated for mining purposes under 45.1-222 or 45.1-225.1 of the *Code of Virginia*.

The height of a dam is defined as the vertical distance from the streambed at the downstream toe to the top of the dam. The capacity of a dam is defined as the volume capable of being impounded at the top of the dam.

Dams are classified with a *hazard potential* depending upon the downstream losses anticipated in event of failure. Hazard potential is not related to the structural integrity of a dam but strictly to the potential for adverse downstream effects *if* the dam were to fail.

- Class I - dams which upon failure would cause probable loss of life or excessive economic loss
- Class II - dams which upon failure could cause possible loss of life or appreciable economic loss
- Class III - dams which upon failure would not likely lead to loss of life or significant economic loss
- Class IV - dams which upon failure would not likely lead to loss of life or economic loss to others

The owner of each regulated Class I, II or III dam is required to apply to the Soil and Water Conservation Board for an operation and maintenance certificate. The application must include an assessment of the dam by a licensed professional engineer along with an operation and maintenance plan and an emergency action plan. The emergency action plan is filed with the appropriate local emergency official and the Department of Emergency Services. The board issues certificates to the owner for a period of six years. If a dam has some deficiency but does not pose imminent danger, the board may issue a two-year *conditional certificate* during which time the owner is to correct the deficiency.

After a dam is certified by the board, periodic inspections by an engineer are required at the following frequency: Class I - each two years; Class II - each three years; Class III each six years upon renewal of the certificate

In addition the owner must inspect the dam in those years when an engineer's inspection is not required. Certificates are not required for Class IV dams, but the owner must file an inventory report each six years and an inspection report each year. Each owner is fully responsible for the safety of his or her dam and is expected to keep it in a safe operating condition. Permits are issued by the board for construction of new dams and alterations to existing dams.

Downstream Hazard Potential

With the National Dam Inspection Act (P.L. 92-367) of 1972, Congress authorized the U.S. Army Corps of Engineers (USACE) to inventory dams located in the United States. The Water Resources Development Act of 1986 (P.L 99-662) authorized USACE to maintain and periodically publish an updated National Inventory of Dams (NID). The Water Resources Development Act of 1996 (P.L. 104-303), Section 215, re-authorized periodic update of the NID by USACE, and continued a funding mechanism. The USACE continues to work closely with the Association of State Dam Safety Officials (ASDSO), FEMA, and other state and federal agencies to update and publish the NID.

The NID includes a classification for downstream hazard potential for each dam in the inventory as shown in Table 19. The *Downstream Hazard Potential Code* indicates the potential hazard resulting from failure or misoperation of the dam or facilities: L for Low; S for Significant; H for High. Definitions, as accepted by the Interagency Committee on Dam Safety, are as follows:

1. Low Hazard Potential - Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner’s property.
2. Significant Hazard Potential - Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
3. High Hazard Potential - Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

Table 20
National Inventory of Dams Data, 2003

Dam Name	NID ID	River	EAP	NID Storage	Year Completed	Hazard	Locality	Owner Name
Blue Ridge Estates Dam	VA02304	Laymantown Creek	Y	108.00	1950	H	Botetourt County	Emerald Lake Property, Inc.
Carvin Cove Dam	VA02301	Carvins Creek	Y	23,000.00	1946	H	Botetourt County	City of Roanoke
Clifton Forge Dam	VA00503	Smith Creek	Y	318.00	1949	H	Alleghany County	City of Clifton Forge
Gathright Dam	VA00501	Jackson River	Y	42,1500.00	1978	H	Alleghany County	CENAO
Johns Creek Dam #1	VA04502	Johns Creek	Y	3,759.00	1967	H	Craig County	Mountain Castles SWCD
Johns Creek Dam #2	VA04501	Little Oregon Creek	Y	1,334.00	1967	H	Craig County	Mountain Castles SWCD
Johns Creek Dam #3	VA04503	Mud Lick Branch	Y	292.00	1968	H	Craig County	Mountain Castles SWCD
Johns Creek Dam #4	VA04504	Dicks Creek	Y	1,022.00	1966	H	Craig County	Mountain Castles SWCD
Loch Haven Lake Dam	VA16102	Tr-Deer Branch Cr	Y	108.00	1930	S	Roanoke County	Harriet S. Preece
Niagara Dam	VA16101	Roanoke	Y	425.00	---	H	Roanoke County	Appalachian Power Company
Orchard Dam	VA16103	Tributary-Glade Creek	Y	158.00	1984	H	Roanoke County	F & W Development
Orchard Lake Dam	VA02302	Tributary-Tinker Creek	N	105.00	1957	S	Botetourt County	R. W. Woodson
Pond Lick Branch Dam	VA00502	Pond Lick Branch	N	20.00	1962	L	Alleghany County	Ralph Burroughs, Jr.
Rainbow Forest Dam [1]	VA02303	Laymantown Creek	Y	155.00	---	H	Botetourt County	Rainbow Forest Recreational Assoc
Spring Hollow Reservoir Dam	VA16104	Tr-Roanoke River	Y	11,410.00	1994	H	Roanoke County	Roanoke County
Westvaco #2 Flyash Lagoon Dam	VA00504	Dunlap Creek Off Stream	Y	1,496.00	1977	S	Alleghany County	Westvaco, Bleached Board Division

Source: *National Inventory of Dams, Water Control Infrastructure*, U.S. Army Corps of Engineers in cooperation with FEMA's National Dam Safety Program, 2003. 1. Rainbow Forest Dam has a 1-year conditional operating certificate that ends in December 2005.

Hurricane

Since 1871, 123 hurricanes and tropical storms have affected Virginia taking 228 lives and costing the commonwealth over a billion dollars in damages. The eye of 69 tropical cyclones has tracked directly across Virginia. Eleven have made landfall on or close (within 60 miles) to the Virginia Coast. Virginia averages one hurricane a year. Some years go by with no storms while others years threaten the Commonwealth with multiple storms sometimes, just days or weeks apart.

The majority of hurricanes (61 percent) and tropical storms that have affected Virginia have originated in the Atlantic Ocean. The storm begins as a disturbance moving off the west coast of Africa near the Cape Verde Islands. It gains strength over the very warm equatorial waters. Twenty-six percent of the tropical cyclones that affect Virginia originate in the Caribbean waters and eight percent in the Gulf of Mexico. Three storms (2.5%) originated in the eastern Pacific. They traversed Central America into the Gulf of Mexico before moving northeast toward Virginia.

Hurricanes often spawn tornadoes across Mid-Atlantic region that have, at times, been strong and deadly. This century, 15 hurricanes, tropical storms or their remnants have spawned tornadoes in Virginia. Hurricane David in 1979 spawned 34 tornadoes, of which, eight were in Virginia. Tornadoes struck five counties and three cities from Norfolk in the southeast to near Leesburg in the far north. One person was killed, 25 were injured and damages were close to $14 million.

At this time NOAA, the National Weather Service and other agencies are unable to predict the occurrence and location of future hurricanes. *Based on past events it is likely that hurricanes will continue to impact the Roanoke Valley – Alleghany Region in the future.*

Karst

Karst and sinkholes were not identified as a natural hazard of concern by the localities participating in the regional pre-disaster mitigation plan process due to the localized nature of hazards caused by sinkholes – typically impacting only one structure or a short section of road. Lack of adequate historical data on sinkhole hazard events and lack of complete, detailed mapping of karst/sinkholes also makes it difficult to designate these geologic features as "natural hazards."

Figure 7

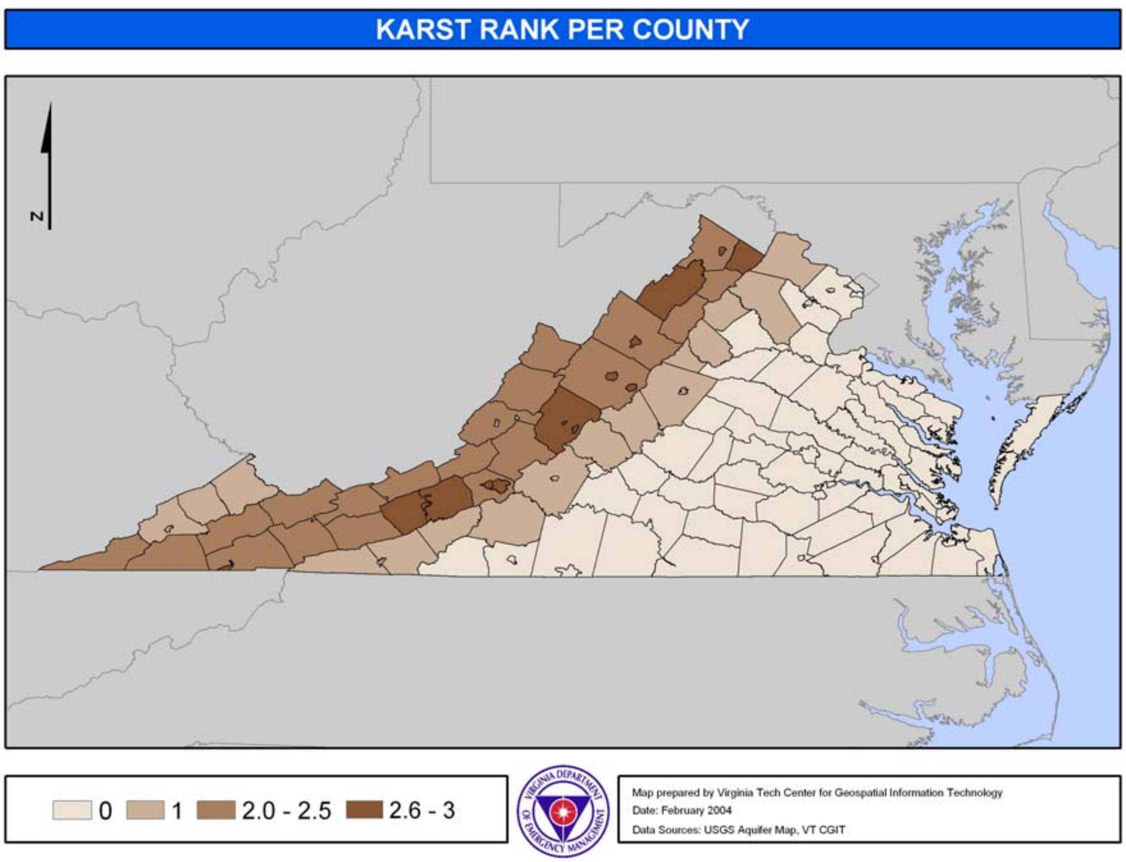


Figure 7 shows the generalized USGS karst mapping was converted to illustrate risk. For jurisdictions with some karst area, a hazard from 3 (high) to 2 (medium) was calculated based on an area-weighted average. Jurisdictions neighboring these counties were assign 1 (low) and all others were assigned 0 (none).

Table 21
Karst Areas in the
Roanoke Valley-Alleghany Region

Locality	Estimated % Karst Terrain	Major Karst Development Areas
Alleghany County (incl. City of Covington, and Towns of Clifton Forge and Iron Gate)	30	Jackson River Valley Potts Creek Valley Warm Springs Valley
Botetourt County (incl. Towns of Buchanan, Fincastle and Troutville)	20	Catawba Creek Valley Timber Ridge
Craig County (incl. Town of New Castle)	30	Sinking Creek Valley Potts Creek Valley
Roanoke County (incl. cities of Roanoke and Salem and Town of Vinton)	20	Roanoke Valley Minor Valleys

Source: Virginia Speleological Survey, http://www.virginiacaves.org, 2005.

Localities should be aware of how environmentally sensitive karstlands can be. Sinkholes, in particular, pose several problems that ultimately affect groundwater in karstic terrain and delicate cave ecosystems. Environmental concerns included: (1) introduction of contaminants and pollutants into the groundwater, (2) catastrophic collapse and gradual subsidence of the land surface, and (3) flooding during or following intense storms.

Karstic terrain, particularly that of moderate to high sinkhole density, thus imposes constraints on land use. Mismanagement of karstlands, whether through unsupervised development, poor farming practices, improper waste disposal, or other means, will often damage groundwater resources, cave ecosystems, or man-made structures built on karst.

In the report Natural Hazard Mitigation Planning For Karst Terrains in Virginia, the researcher found that despite an extensive amount of karst terrain in many communities in western Virginia, few communities use comprehensive land use planning and management approaches for development on karst terrain. A survey of local governments, conducted for the Cave Conservancy of the Virginias by the Urban Affairs and Planning Department at Virginia Tech in 2003, indicated that few communities in western Virginia have adopted land use planning and management tools to minimize karst terrain hazard risks. This statement is also true of the localities within the Roanoke Valley-Alleghany Regional Commission.

One of the first steps in the development of any natural hazard mitigation plan is the identification and mapping of natural hazards. Many jurisdictions identify karst features using 7-1/2 minute U.S.G.S. topographic maps (map scale of 1:24,000 and a contour interval of 20-feet) and/or Natural Resource

Conservation Service county soil surveys (map scales generally range from 1:12,000 to 1:63,360 (Natural Resources Conservation Service, 2003). Both of these map scales prove too large to correctly identify many karst features present on the landscape. The Virginia Department of Conservation and Recreation estimates that in some parts of Virginia standard 1:24,000 topographic maps show less than 50% of the karst features present on the landscape. For these reasons, a smaller, more detailed mapping scale is necessary for appropriate consideration of karst terrain hazards on individual parcels of land.

Localities within the RVARC should work with Virginia Karst Mapping Project, Virginia Speleological Survey, the USGS and other appropriate agencies to identify karst areas and sinkholes, maps these sites, and provide this information to local governments to use as a land use and natural hazards planning tool.

By combining karst GIS spatial and attribute data from state, regional, and local sources, including karst feature buffers and overlay areas, local governments could create a valuable natural hazard planning tool. Natural Hazard Mitigation Planning For Karst Terrains in Virginia recommends that including GIS data for abandoned wells, active wells and springs, septic systems, source water protection boundaries, hazardous waste storage sites, ground water dye tracings, streams, etc. to enhance this planning tool.

The four-step planning process proposed in Natural Hazard Mitigation Planning For Karst Terrains in Virginia, serves as an example for local governments to follow in the development of local karst hazard mitigation plans. The process starts with community education and partnership building to develop community support and commitment for the subsequent steps in the planning process. The karst terrain risk assessment and vulnerability analysis clarifies the hazards that local karst terrain poses to a community. In the final two steps, local governments develop both regulatory and non-regulatory mitigation strategies to minimize community exposure to local karst terrain natural hazards. By using a karst terrain buffer and overlay hierarchy local governments can target regulatory and non-regulatory mitigation strategies to those karst areas that pose the highest natural hazard risks.

Karst Terrain Hazard Mitigation Plan Development Process

I. Community Education and Partnership Building
II. Karst Terrain Hazard Assessment
- A. Develop a karst feature classification system
- B. Develop a karst buffer and overlay hierarchy system
- C. Develop geographic information system capabilities for karst terrain hazard planning

III. Develop Regulatory Karst Terrain Hazard Mitigation Strategies
- A. Update the subdivision ordinance to reflect community goals and objectives for development on karst terrain
- B. Develop a karst terrain zoning overlay district requiring:
  - i. effective karst feature buffers
  - ii. geotechnical studies for development on karst terrain
  - iii. karst terrain related performance standards
- C. Enforce Virginia stormwater management regulations
- D. Enforce Virginia erosion and sediment control regulations
- E. Enhance Virginia septic system regulations to better address the unique geo-hydrology of karst terrain
- F. Develop spring and wellhead protection policies that reflect the unique geo-hydrology of karst terrain

IV. Develop Non-Regulatory Karst Terrain Hazard Mitigation Strategies
- A. Use capital improvements programming to steer development away from high-risk karst terrain
- B. Encourage voluntary land use restrictions in karst terrains through the use of:
  - i. Conservation easements
  - ii. Purchase of development rights
  - iii. Agricultural and forestal districts
  - iv. Land use assessment and taxation programs

Source: Natural Hazard Mitigation Planning For Karst Terrains in Virginia, B. P. Belo, 2003.

References:

Natural Hazard Mitigation Planning For Karst Terrains in Virginia, Bradley Paul Belo, 2003.

Virginia Speleological Survey, Project Areas, http://www.virginiacaves.org, 2005.

Living on Karst: A Reference Guide for Landowners in Limestone Regions, Cave Conservancy of the Virginias, 1997.

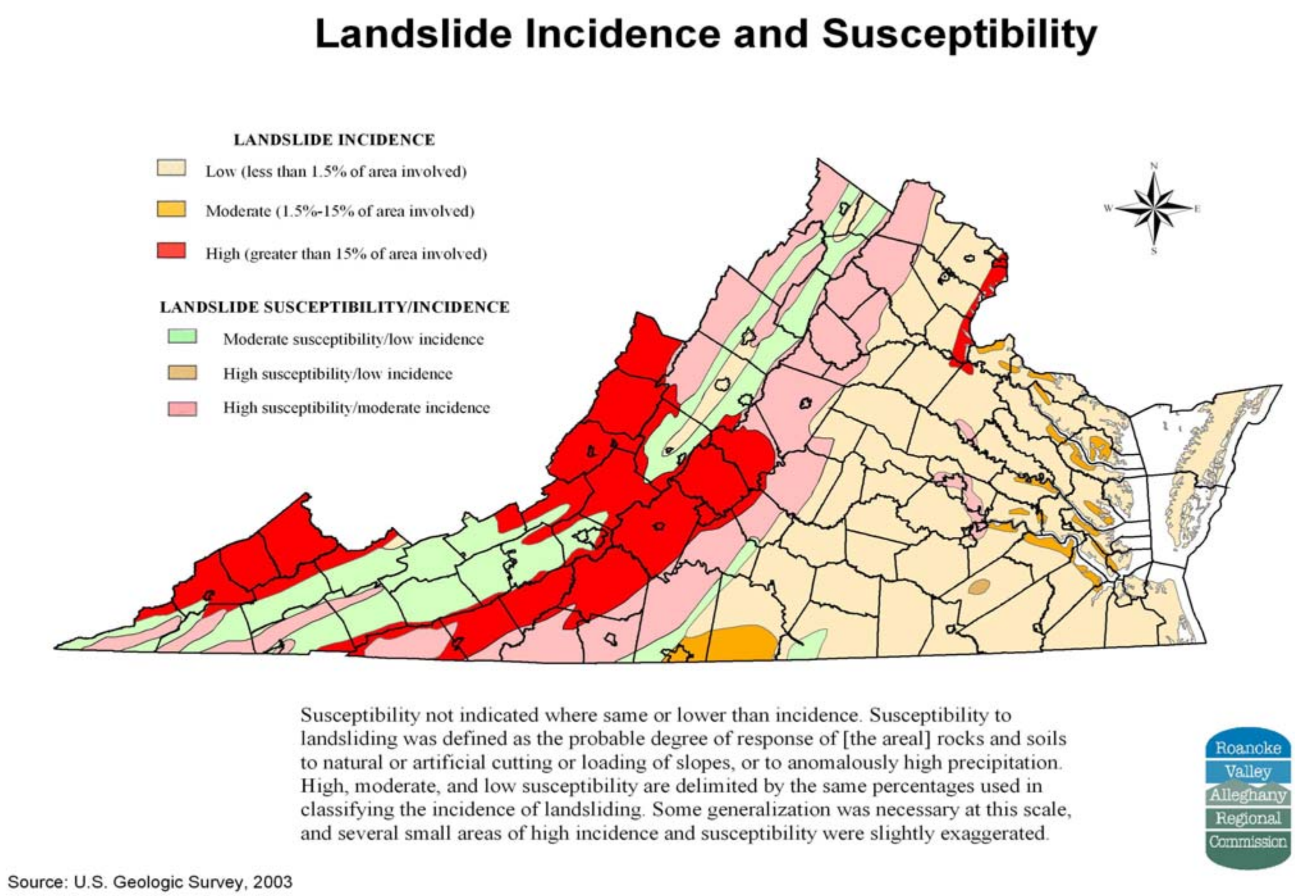
Living With Sinkholes, Virginia Cave Board, Virginia Department of Conservation and Recreation.

Landslide

All 50 states and the U.S. Territories experience landslides and other ground failure problems; 36 states have moderate to highly severe landslide hazards. The greatest landslide damage occurs in the Appalachian, Rocky Mountain, and Pacific Coast regions and Puerto Rico.

The map below is a version of U.S. Geological Survey Professional Paper 1183, Landslide Overview Map of the Conterminous United States. This map delineates areas where large numbers of landslides have occurred and areas that are susceptible to landslides in the conterminous United States. The purpose of the map is to give the user a general indication of areas that may be susceptible to landslides. It is not suitable for local planning or site selection.

Figure 8
Landslide Incidence and Susceptibility



The Blue Ridge region of Virginia has experienced landslides throughout its history. Boulders, uprooted trees and tallis are all evidence of these events that can be found throughout the region. Records show that landslides and debris flows in the Appalachian Mountains occur when unusually heavy rain from hurricanes and intense storms soaks the ground, reducing the ability of steep slopes to resist the downslope pull of gravity. Scientists have documented 51 historical debris-flow events between 1844 and 1985 in the Appalachians – most of them in the Blue Ridge region. (Debris Flow Hazards in the Blue Ridge of Virginia, USGS Fact Sheet 159-96P. L. Gori and W. C. Burton, 1996).

Landslide inventory and landslide susceptibility maps are critically needed in landslide prone regions of the nation. These maps must be sufficiently detailed to support mitigation action at the local level. To cope with the many uncertainties involved in landslide hazards, probabilistic methods are being developed by USGS and its partners to map and assess landslide hazards. Risk assessments estimate the potential economic impact of landslide hazard events. Landslide inventory and susceptibility maps and other data are a critical first step and prerequisite to producing probabilistic hazard maps and risk assessments, *but these maps and data are not yet available in most areas of the United States nor the Roanoke Valley – Alleghany Region*.

Based on existing data, landslide susceptibility in the Roanoke Valley - Alleghany Region is high in Alleghany County, Botetourt County and the mountainous areas of Craig County and Roanoke County. Landslide occurrence in the urbanized areas of Botetourt County, Roanoke County, Town of Vinton and cities of Roanoke and Salem is rated as moderate susceptibility and low incidence.

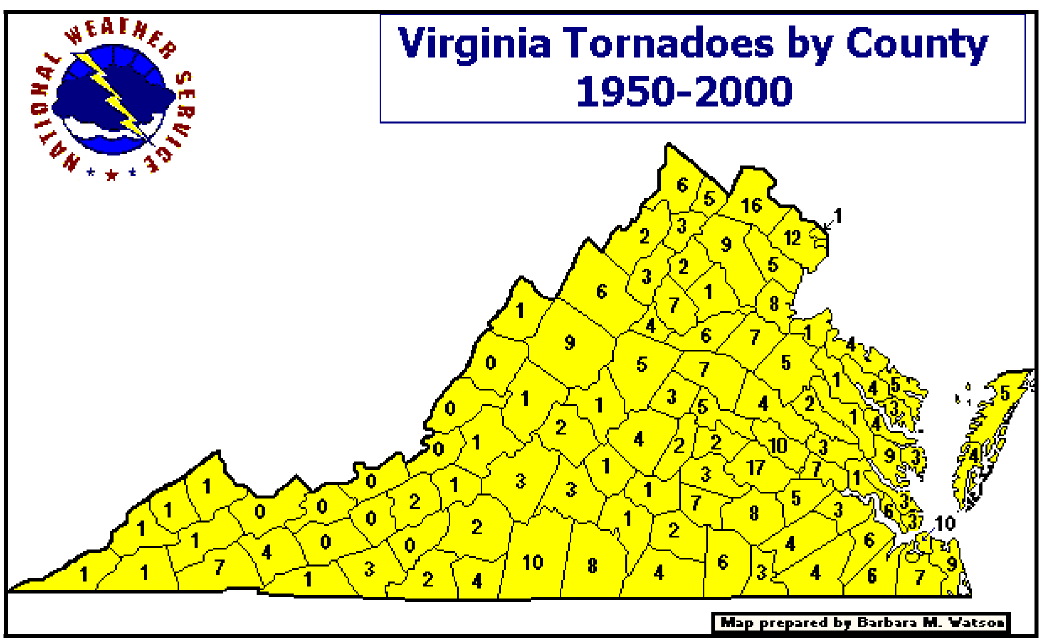
Tornado

Some areas in Virginia do appear slightly more prone than others. It is believed that this is caused by topographical influences on thunderstorms such as the change in low-level wind flow and humidity caused by the orientation of the mountains - known as a "maxima" - and the Chesapeake Bay.

Below is a map showing tornado occurrence by county. One maxima is seen in Northern Virginia to the east of the Blue Ridge. This maxima extends northeast across Maryland into southeast Pennsylvania. A second maxima extends from North Carolina northeast toward Petersburg. Smaller maxims are in the southern Shenandoah Valley near Staunton and Harrisonburg and one that comes up from Tennessee into extreme Southwest Virginia near Bristol. Some bias must also be accounted for by population density with the denser population areas more likely to report a tornado.

At this time NOAA, the National Weather Service and other agencies are unable to predict the occurrence and location of future tornadoes. Based on past events it is likely that tornados will continue to impact the Roanoke Valley – Alleghany Region.

Figure 9
Virginia Tornados by County, 1950-2000



Source: NOAA, National Climatic Data Center.

Wildfire

In order to determine the base hazard factor of specific wildfire hazard sites and interface regions, the following factors must be considered: topographic location, site/building construction and design, fuel profile, defensible space, accessibility, and water availability.

The Department of Forestry has recently completed a Geographic Information System (GIS) - based Wildfire Risk Assessment of the entire state. Agency Firewise Specialists are now actively working to better assess the level of wildfire risk for the more than 4,000 individual, at risk, Wildland Urban Interface communities identified in the Commonwealth, however, this is only the first step in the process. Once communities have been visited and assessed for their level of wildfire risk, positive actions need to be taken to help reduce or mitigate the hazards identified.

Through the use of the GIS, the Virginia Department of forestry has recently identified areas of high, medium and low risk from wildfire. Figure 8, Wildfire Risk Assessment Map, illustrates these areas on a regional level. Locality specific wildfire risk maps are provided in Appendix C of the Plan.

VDOF has developed the Wildfire Risk Assessment to more objectively reflect the potential for wildfire across Virginia. By building a GIS model that assigns relative weights and ranks to input layers, VDOF has produced a map of Wildfire Risk that will help the agency perform community Firewise outreach, better allocate resources, and increase response preparedness. Input layers include slope, aspect, landcover, distance to railroads, distance to roads, population density, and historical fire occurrence. Maps of the model output were sent to each DOF field office for verification. Changes were made to the model weights to better reflect the conditions at the local scale. **This Wildfire Risk Assessment is meant to be used at county or regional scales; it is not as reliable at the site scale**. Maps illustrating wildfire risk for each locality are shown in Appendix C.

The information in the analysis and the GIS is provided by the Virginia Department of Forestry with the understanding that it is not guaranteed to be correct or complete and conclusions drawn from such information are the sole responsibility of the user. While The Virginia Department of Forestry has attempted to ensure that this documentation is accurate and reliable, DOF does not assume liability for any damages caused by inaccuracies in these data or documentation, or as a result of the failure of the data or software to function in a particular manner. DOF makes no warranty, express or implied, as to the accuracy, completeness, or utility of this information, nor does the fact of distribution constitute a warranty. For more detailed information about modeling methodology, go to the GIS Data Downloads page and read the Info file (metadata) for the Wildfire Risk Assessment at the Virginia Department of Forestry at http://www.dof.virginia.gov/gis/dwnld-Statewide-faq.shtml.

Risk is defined as the probability of an event occurring. The wildfire hazard-risk assessment consists of six inputs described above. These six inputs are weighted according to their importance and geographical location (coastal plain, piedmont and mountain regions). For example, homes within or adjacent to wildland fuels and in areas of high fire occurrence, on steep slopes may have a higher risk of burning. Homes that are not located near wildland fuels, in areas of low fire occurrence and in relatively flat terrain may have a low risk of burning. State, county and local governments or communities need to know where their high-risk areas are, the factors that make those areas at risk and what can be done to mitigate this risk.

The areas at greatest risk for forest fire are those at the urban-wildland interface, or where people and forests meet. A wildfire mitigation project is currently underway that will update and refine the wildfire risk analysis described above. Another goal of this project is to improve decision-making capabilities for fire suppression and prevention activities by adding to the GIS database. Data are being collected on locations and attributes of wildfire suppression resources, woodland home communities, and historical fire incidents. Understanding the spatial relationship of these and other features will help VDOF concentrate their prevention education, resource allocation, and emergency response efforts where fire poses the greatest risk.

Model Inputs And Analysis Development

Due to the importance wildfire risk in the region and the need for local governments and citizens to have a better understanding of this risk, a detailed description of the Virginia Department of Forestry's model inputs and analysis development is described below.

The Virginia Department of Forestry (VDOF) used GIS to develop a statewide spatial Wildfire Risk Assessment model that aims to: (1) identify areas where conditions are more conducive and favorable to wildfire occurrence and wildfire advancement; (2) identify areas that require closer scrutiny at larger scales; and (3) examine the spatial relationships between areas of relatively high risk and other geographic features of concern such as woodland home communities, fire stations and fire hydrants. This model incorporates data from several other state and federal agencies including land cover, demographics, transportation corridors and topography. Differences in the relative importance of model variables necessitated the use of three individual analyses broken along Virginia's mountain, piedmont and coastal plain physiographical regions. The three model results were merged to produce the statewide Wildfire Risk Assessment.

In 2002 and 2003, VDOF examined which factors influence the occurrence and advancement of wildfires and how these factors could be represented in a GIS model. VDOF determined that historical fire incidents, land cover (fuels surrogate), topographic characteristics, population density, and distance to roads were critical variables in a wildfire risk analysis. DOF gathered these data layers, sometimes creating them, and used them in a raster-based weighted aggregate model.

The weights assigned to input variables (specifically topographic variables) differ depending on the physiographic zone being represented because the topographic characteristics of the landscape change dramatically across Virginia. The resolution of the model is defined by the coarsest resolution of input data. The National Land Cover Dataset and National Elevation Dataset both have a spatial resolution of 30-meter pixels, therefore all other layers were created or resampled to this resolution. Each input layer is normalized on an interval scale from 0 to 10 with 10 representing the characteristics of each layer that have the highest wildfire risk.

Density Of Historical Wildfires. · Premise: Wildfire density was mapped to identify areas where wildfires have historically been relatively prevalent and relatively absent. It is assumed that these spatial patterns will remain similar in the future. · Data Preparation: Point locations for wildfires occurring in the years 1995 - 2001 inclusive were obtained from the George Washington and Jefferson National Forests and Shenandoah National Park. They were merged with the point wildfire locations documented by VDOF. Generally, VDOF does not document fires occurring on federal lands and unsuccessful attempts were made to obtain wildfire GIS data from most of the remaining federal agencies that manage land in the Commonwealth. Using ESRI's Spatial Analyst for ArcView 8.2, a Kernel density function was applied to the point data using a search radius of 5000 meters. The output grid was reclassified into ten classes using the natural breaks classification method and then assigned an interval value from 1 to 10.

Land Cover · Premise: Land Cover data reveal the type of wildfire fuels that are likely to be found in different areas. The USGS Multi-Resolution Land Cover data were used in this model to identify areas of the state where there are fuel types that ignite more easily, burn with greater intensity and facilitate a greater rate of wildfire advancement. Fuels data of this resolution and scale have their limitations and the lack of detailed fuel models is commonly recognized as the most prominent limitation in the various types of wildfire risk modeling. Although some advanced processing of remotely sensed data can be used to estimate canopy crown closure and moisture content, data of these types can rarely divulge the degree of fuel loading within a pixel.

Data Preparation: Each fuel type identified by the MRLC data was rated on a 0 to 10 interval scale as follows: Water: NoData* Low-Intensity Development: 3 High-Intensity Development: 2 Hay, Pasture, Grass: 6 Row Crops: 2 Probable Row Crops: 3 Conifer (Evergreen) Forest: 10 Mixed Forest: 9 Deciduous Forest: 8 Woody Wetlands: 2 Emergent Wetlands: 1 Barren (Quarry, Coal, Beach): 0 Barren Transitional (includes clear-cut): 2

Water was classified as NoData due to the undesirable effect a value of zero would have on the final output. Because land cover is weighted relatively high, the initial out put would contain very low values over water bodies if the water class was assigned a value of zero. This effect seems appropriate, but these low values would have a profound and undesired effect on the surrounding areas when the neighborhood function was executed. Hence, the water class was initially classified as NoData.

Fire Resources

Not only are we at risk from naturally occurring wildfires but we are also responsible for wildfire ignition through deliberate actions or carelessness. In the past low rural population levels plus adequate suppression resources have kept the loss of life and property low.

A first concern about wildland fire is the rapidly growing number of woodland home communities that are evident all across Virginia. In the past, rural communities were typically scattered agricultural operations. Today, new rural communities are more likely to be residential communities whose residents commute to urban jobs. These rural communities are becoming increasingly attractive to the urban populations.

Fire organizations, which have found their roots in rural America, evolved into two separate groups, the more rural volunteer organization and the professional urban fire organizations each with its own distinct philosophy. Fires within or threatening the wildland-urban interface have elements of both wildland and urban fires. For this reason both organizations become involved in protection and suppression of wildfires.

The Wildfire Risk maps in Appendix C show the location of these woodland home communities, the fire departments and other firefighting resources as they relate to the various levels of wildland fire risk.

Resources are mapped at a regional scale due to the nature of rural emergency services that are not limited by governmental boundaries; for example the Buchanan Volunteer Fire Department would respond to a fire on Purgatory Mountain which is located outside of the town limits in Botetourt County.

The Project Impact Roanoke Valley Hazard Analysis report identified subdivisions that were considered at risk for wildfire based on the Virginia Department of Forestry Fire Hazard Rating. The Project Impact Roanoke Valley Hazard Analysis Workgroup identified 1,727 Roanoke Valley homes in subdivisions (the inventory did not include outlying single-family homes) at risk for wildfire and potential damage cost of $296,000,000. If all lots in these subdivisions were developed there would be 2,455 homes in with potential to be damaged, or destroyed, by wildfires.

The specific number of homes and businesses that could be impacted by wildfire in the remainder of the Roanoke Valley Alleghany Regional Commission has not been documented at this time. A summary of fires that have occurred from the Virginia Department of Forestry and local government sources provides some insight to the danger from wildfire in the region in Table 21.

Table 22

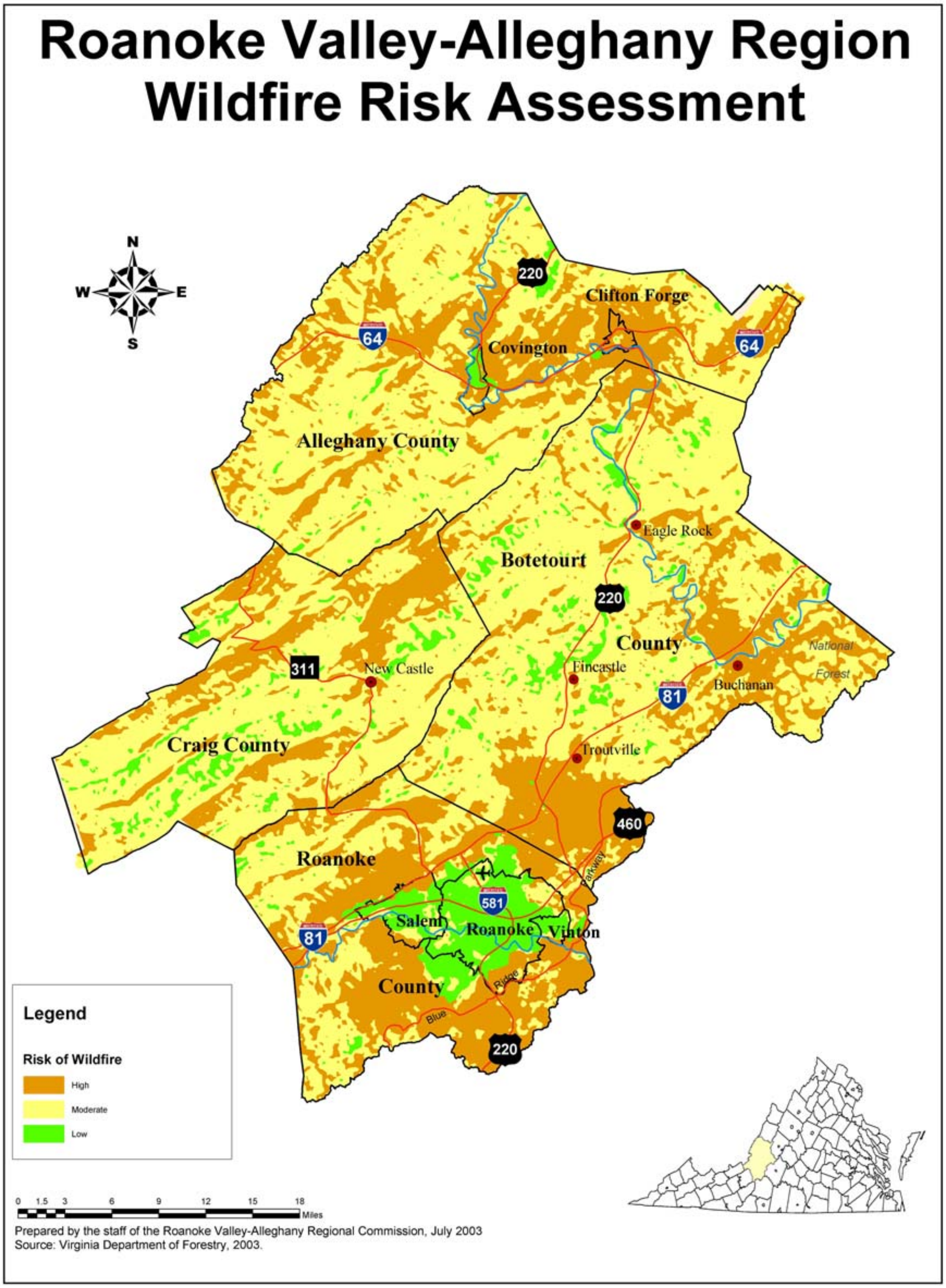
Wildfire Statistics, 5-Year Average

Locality*	Total Number of Wildfires	Total Acres Burned	Average Size Fire (ac.)
Alleghany County	40	337.4	8.44
Botetourt County	49	1,437	29.33
Craig County	25	359	14.36
Roanoke County	35	360.7	10.3

* Data includes cities and towns located within each county.
Source: Fire Facts, Virginia Department of Forestry, 2003 and Craig County Emergency Services Office.

Based on past events it is likely that wildfires will continue to impact the Roanoke Valley – Alleghany Region in the future.

Figure 10
Regional Wildfire Risk Assessment Map



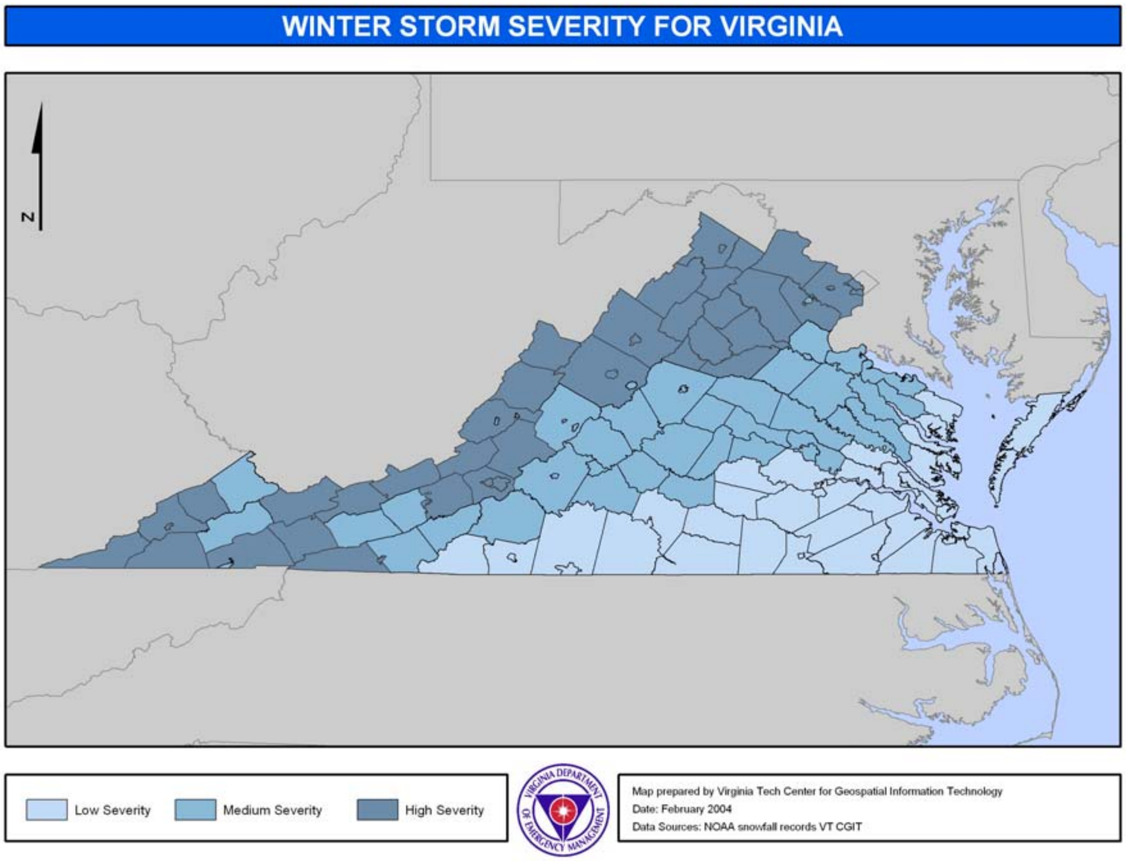
Winter Storm

When heavy snow falls quickly, commuters are often stranded, the delivery of essential goods and supplies stopped, and emergency responses delayed. Heavy snow can knock down trees, power and telephone lines, and collapse roofs. In rural areas, livestock and pets can die while homes are isolated for days. Additionally, the costs of snow removal, damage repair, and lost business can have a serious economic impact. The dangers of winter are intensified when extremely cold temperatures accompany a winter storm. Extremely cold weather is most dangerous to infants and the elderly. Additionally, freezing temperatures can cause damage to vegetation, wildlife, pets, and even homes and businesses as pipes freeze and burst. Streams can freeze; creating ice jams that can cause flooding. When snow is driven by the wind, the result is blizzard conditions that are often blinding and deadly.

Winter ice storms are frequent in the region. When rain falls onto a surface that is below freezing, it freezes to that surface. Anything the freezing rains contact becomes glazed with accumulating ice. Even modest accumulations of ice can quickly down trees, electrical and telephone wires, communications towers and antennas critical for emergency communications. Repair of these utilities can take days, leaving citizens without power or telephone service. Light accumulations of ice are hazardous to motorists and pedestrians.

The entire region is vulnerable to winter storms based on the evidence of past events. Winter storms impact entire jurisdictions. The potential impacts to each locality can be seen on the General Inventory maps in Appendix C. The Virginia Department of Emergency Management ranks all of the localities within the RVARC regions as being at risk for "high severity" winter storms. A typical winter in the Roanoke Valley-Alleghany region is relatively mild, but Arctic blasts and Gulf moisture or coastal storms driven inland have historically combined to deliver serious winter weather. There is potential for dangerous winter weather from November to as late as May. Severe winter weather might come in the form of snow, ice, sleet and freezing rain, or blustery cold temperatures and winds. *Based on past events it is likely that winter storms will continue to impact the Roanoke Valley – Alleghany Region in the future.*

Figure 11


WINTER STORM SEVERITY FOR VIRGINIA
N
Low Severity
Medium Severity
High Severity
Map prepared by Virginia Tech Center for Geospatial Information Technology
Date: February 2004
Data Sources: NOAA snowfall records VT CGIT

(BLANK)

Chapter 4
Loss Estimation

Loss estimates were calculated for flooding only. Other disasters are too variable and widespread to determine any useful loss estimates.

Methodology for Flood Damage Estimates

The methodology for determining flood losses varied depending on the data available for each locality. Structure losses were assumed to be 100 percent. Content losses for residential structures were estimated to be 50 percent of the structure value. Content losses for commercial structures were estimated to be 100 percent of the structure value. The average number of people per household, from the 2000 US Census, was used to estimate the number of people affected by residential structure loss. Data was not available to estimate other losses relating to roads or other infrastructure.

Alleghany County, Craig County, Clifton Forge, Iron Gate and New Castle

Digital flood plain mapping was not available for these areas. In Alleghany County and Craig County, streams with 100-year floodplains were identified using 1987 and 1990 FIRM (FEMA Flood Rate Insurance Program) maps respectively. Those stream segments were buffered 100 meters using a GIS to represent an estimated floodplain. Digital orthophoto quarter quadrangles (DOQQ) from the USGS (United States Geologic Survey) were overlaid with the buffered streams. Structures within the buffered stream segments were identified on the photos and counted. The structure counts were summarized by US Census block group level. The median residential structure values from the US Census were then used to estimate residential structure damage. The average commercial structure value from Botetourt County ($121,378) was applied to commercial structures in Craig and Alleghany counties. For Clifton Forge, Iron Gate and New Castle, the streams were not buffered. The actual floodplains from the FIRM maps were digitized on the screen to better estimate the number of structures in the floodplain.

City of Covington

The City of Covington had digital maps of structure footprints and parcels. Since a digital floodplain map was not available, the hardcopy FIRM map was digitized on the screen as an overlay. Structures in the floodplain were then isolated by a basic GIS query. Structures less than 600 square feet were removed and assumed to be outbuildings. Structures over 3,000 square feet (ground floor only) were assumed to be commercial. The residential structures were assigned the median home value based on the 2000 Census block group data. The commercial structures were overlaid on the digital parcel map to find 65 corresponding parcels. The structure values were then looked up in the real estate database for the 65 commercial parcels in the floodplain. Note: The lack of common unique identifier prevented an automated joining of the parcel layer and real estate database for use in the GIS.

Botetourt County, Buchanan, Troutville and Fincastle

FEMA “Q3” (digital versions of the hardcopy FIRM maps) files were available for use in the GIS. Addressed structures were obtained from Botetourt County’s E-911 system and overlaid with the 100-year floodplains. The real estate database was linked to the parcels, and the parcels with structures in the floodplain were identified. Structure values were then calculated using the assessed value in the real estate database. Commercial values in Buchanan, Troutville and Fincastle appeared to be too low, so they were adjusted slightly toward the countywide commercial average. Zoning information, in the form of a GIS layer, was used to distinguish commercial from residential structures.

City of Salem, City of Roanoke, Town of Vinton and Roanoke County

The Roanoke Valley localities have performed approximately 3,005 elevation surveys (elevation certificates) for structures located near or in floodplains over the past few years. However, not all structures in the floodplains have been identified or surveyed. Local officials have indicated that only a small percentage of structures have not yet been identified or surveyed. All of the localities also have digital “Q3” floodplain mapping and parcel data. However, since the floodplain determination had already been conducted for the 3005 elevation certificates, the “Q3” data was not used. Using the parcel identification number in the elevation certificates, the real estate database was linked to determine structure value. As in Botetourt County, general zoning was used to distinguish commercial structures from residential structures. While some localities had land use data, the level of detail made it too difficult to collapse to the two basic commercial and residential categories.

Table 23
Alleghany County Flood Damage Estimates
(Unincorporated Areas)

	Number of Parcels		Value of Structures			
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain	Contents Replacement Value	Number of People Affected
Residential		383		$28,851,100	$14,425,550	942
Commercial		141		$17,114,301	$17,114,301	unknown
Total		524		$45,965,401	$31,539,851	na
*Parcels with structures	Estimated Total Loss				$77,505,252	

Source: Roanoke Valley-Alleghany Regional Commission, 2003.

Table 24
Botetourt County Flood Damage Estimates
(Unincorporated Areas)

	Number of Parcels		Value of Structures			
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain	Contents Replacement Value	Number of People Affected
Residential		365		$12,796,700	$6,398,350	934
Commercial		91		$11,045,400	$11,045,400	unknown
Total	21,389	456	$848,660,900	$23,842,100	$17,443,750	na
*Parcels with structures	Estimated Total Loss				$41,285,850	

Source: Real Estate Assessment for Botetourt County, 2003; Botetourt County GIS, 2003; and Roanoke Valley-Alleghany Regional Commission.

Table 25
Town of Buchanan Flood Damage Estimates

	Number of Parcels		Value of Structures			
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain	Contents Replacement Value	Number of People Affected
Residential		31		$618,700	$309,350	79
Commercial		20		$3,000,000	$3,000,000	unknown
Total	1,298	51	$22,804,700	$3,618,700	$3,309,350	na
*Parcels with structures	Estimated Total Loss				$6,928,050	

Source: Real Estate Assessment for Botetourt County, 2003; Botetourt County GIS, 2003; and Roanoke Valley-Alleghany Regional Commission.

Table 26
Town of Clifton Forge Flood Damage Estimates

	Number of Parcels		Value of Structures		Contents	Number
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain	Replacement Value	of People Affected
Residential		106		$5,596,800	$2,798,400	235
Commercial		59		$7,161,303	$7,161,303	unknown
Total		165		$12,758,103	$9,959,703	na
*Parcels with structures	Estimated Total Loss				$22,717,807	

Source: Roanoke Valley-Alleghany Regional Commission, 2003.

Table 27
City of Covington Flood Damage Estimates

	Number of Parcels		Value of Structures		Contents Replacement Value	Number of People Affected
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain		
Residential		408		$21,492,900	$10,746,450	906
Commercial		65		$42,000,000	$42,000,000	unknown
Total		473		$63,492,900	$52,746,450	na
*Parcels with structures	Estimated Total Loss				$116,239,350	

Source: City of Covington GIS, 2003; and Roanoke Valley-Alleghany Regional Commission 2003.

Table 28
Craig County Flood Damage Estimates
(Unincorporated Areas)

	Number of Parcels		Value of Structures		Contents Replacement Value	Number of People Affected
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain		
Residential		122		$10,418,800	$5,209,400	299
Commercial		12		$1,456,536	$1,456,536	unknown
Total		134		$11,875,336	$6,665,936	na
*Parcels with structures	Estimated Total Loss				$18,541,272	

Source: Roanoke Valley-Alleghany Regional Commission, 2003.

Table 29
Town of Fincastle Flood Damage Estimates

	Number of Parcels		Value of Structures			
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain	Contents Replacement Value	Number of People Affected
Residential		0		$0	$0	0
Commercial		3		$50,500	$50,500	unknown
Total	334	3	$5,510,200	$50,500	$50,500	na
*Parcels with structures	Estimated Total Loss				$101,000	

Source: Real Estate Assessment for Botetourt County, 2003; Botetourt County GIS, 2003; and Roanoke Valley-Alleghany Regional Commission.

Table 30
Town of Iron Gate Flood Damage Estimates

	Number of Parcels		Value of Structures			
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain	Contents Replacement Value	Number of People Affected
Residential		6		$250,800	$125,400	15
Commercial		3		$364,134	$364,134	unknown
Total		9		$614,934	$489,534	na
*Parcels with structures	Estimated Total Loss				$1,104,468	

Source: Roanoke Valley-Alleghany Regional Commission, 2003.

Table 31
Town of New Castle Flood Damage Estimates

	Number of Parcels		Value of Structures			
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain	Contents Replacement Value	Number of People Affected
Residential		4		$365,200	$182,600	10
Commercial		1		$121,378	$121,378	unknown
Total		5		$486,578	$303,978	na
*Parcels with structures	Estimated Total Loss				$790,556	

Source: Roanoke Valley-Alleghany Regional Commission, 2003.

Table 32
City of Roanoke Flood Damage Estimates

	Number of Parcels		Value of Structures		Contents Replacement Value	Number of People Affected
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain		
Residential	31,268	373		$24,216,200	$12,108,100	821
Commercial	3,101	158		$83,051,200	$83,051,200	unknown
Total	46,501	531	$4,027,205,145	$107,267,400	$95,159,300	na
*Parcels with structures	Estimated Total Loss				$202,426,700	

Source: Flood Elevation Certificates, City of Roanoke 2002; City of Roanoke Real Estate Assessment, 2003; and Roanoke Valley-Alleghany Regional Commission, 2003.

Table 33
Roanoke County Flood Damage Estimates
(Unincorporated Areas)

	Number of Parcels		Value of Structures		Contents Replacement Value	Number of People Affected
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain		
Residential	29,285	417		$31,341,900	$15,670,950	1005
Commercial	3,074	46		$57,097,400	$57,097,400	unknown
Total	43,455	463	$4,024,638,401	$88,439,300	$72,768,350	na
*Parcels with structures	Estimated Total Loss				$161,207,650	

Source: Flood Elevation Certificates, 2002; Roanoke County Real Estate Assessment, 2003; and Roanoke Valley-Alleghany Regional Commission, 2003.

Table 34
City of Salem

	Number of Parcels		Value of Structures		Contents Replacement Value	Number of People Affected
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain		
Residential	7,452	338		$18,115,000	$9,057,500	784
Commercial	941	52		$14,782,100	$14,782,100	unknown
Total	8,393	390	$1,114,493,600	$32,897,100	$23,839,600	na
*Parcels with structures	Estimated Total Loss				$56,736,700	

Source: Flood Elevation Certificates, 2002; City of Salem Real Estate Assessment; and Roanoke Valley-Alleghany Regional Commission, 2003.

Table 35
Town of Troutville

	Number of Parcels		Value of Structures		Contents Replacement Value	Number of People Affected
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain		
Residential		38		$2,557,400	$1,278,700	97
Commercial		24		$2,500,000	$2,500,000	unknown
Total	316	62	$13,365,200	$5,057,400	$3,778,700	na
*Parcels with structures	Estimated Total				$8,836,100	

Source: Real Estate Assessment for Botetourt County, 2003; Botetourt County GIS, 2003; and Roanoke Valley-Alleghany Regional Commission.

Table 36
Town of Vinton

	Number of Parcels		Value of Structures		Contents Replacement Value	Number of People Affected
	Total Parcels*	Number in Floodplain*	All Structures	Structures in Floodplain		
Residential		50		$3,886,300	$1,943,150	115
Commercial		23		$3,331,900	$3,331,900	unknown
Total	3,733	73	$262,943,000	$7,218,200	$5,275,050	na
*Parcels with structures	Estimated Total Loss				$12,493,250	

Source: Flood Elevation Certificates, 2002; and Roanoke Valley-Alleghany Regional Commission, 2003.

(BLANK)

Chapter 5
Lessons Learned

This plan is the Roanoke Valley – Alleghany Region's first attempt at developing a regional pre-disaster mitigation plan. As a result of this effort, we have learned much about the availability of hazard related data, availability and accuracy of local, state and Federal mapping, and attitudes toward planning. This section outlines some of the items that would have made the planning process run more smoothly.

Mapping

Varying levels of local government mapping are available and range from complete parcel level maps in complex GIS systems to paper maps that are revised with pencil and markers. A complete parcel based GIS with assessment data and natural hazard layers such as floodplains would have been a tremendous benefit when performing risk assessment and damage estimates. Without this data it is not possible to calculate accurate estimated losses or level of risk to residences and critical facilities.

While the urban areas of the region are fortunate enough to have GIS, the lack of GIS in rural localities data hampered planning and analysis work.

Usefulness of GIS data varies from locality to locality. For example, one locality's GIS data could not be matched to its tax assessment data due to lack of a unique identifier in the databases. As is often stated, a standard format for GIS and related databases is needed.

State and Federal mapping was used during the planning process. New aerial digital images of Virginia became available too late to be used in the initial writing of the document but will be useful for updates. Aging FIRMs need to be updated, and in some cases completed, for localities in the region.

Local Disaster Planning

Local disaster planning has traditionally focused on response - the Emergency Operations Plan and providing fire, police and rescue services - particularly in rural areas, not on mitigation. A lack of understanding that local governments have a role to play, through planning, zoning, and outreach, in mitigating the impact of natural disasters hampered efforts. The newness of the regulations, lack of guidelines at the beginning of the process, and explaining the concept of pre disaster mitigation were all challenges.

Loss Estimation

It is difficult, if not impossible, to estimate losses without being able to predict where disasters will occur. Earthquakes, tornados, and winter storms could impact any or all of the region while other disasters like wildfires and landslides would be more localized, yet still impossible to predict with any accuracy.

The only disaster with somewhat adequate data (past events and "predicted" areas of future occurrence) is flooding. Loss estimation for localities with GIS layers for parcels, structures and floodplains can be performed although the accuracy of estimates based on assumptions (percent of property or inventory lost) is questionable. An accurate content loss estimate would require reporting from all businesses and residences located in the floodplain which is not available

Participation

The general public and businesses tend to not participate in the planning process - whether it is disaster mitigation or comprehensive planning - unless they feel that they are directly impacted by a plan or project. Additional public participation would have been beneficial.

Data Availability

Much of the data utilized in the plan is readily available at the city and county level only, making it difficult to determine impacts on towns. While Census data is available for towns, employment data, meteorological data, NFIP damage summaries, etc. are not.

Lack of damage data from past disasters made it difficult to accurately assess risk and estimate damages from future events. A more thorough method for documenting damages and maintaining records, either in a database or GIS at the local or State level would be beneficial to disaster mitigation planning.

Chapter 6
Regional Mitigation Goals and Strategies

Project Prioritization and Benefit to Cost Consideration

In developing mitigation strategies for the region and each locality, a wide range of activities were considered in order to achieve the goals and to lessen the vulnerability of the area to the impact of natural hazards. **All goals are dependant on the availability and timeliness of non-local funding.**

Goals and Strategies were prioritized by each locality. Prioritization was completed in order of relative priority – high, medium or low – based on the benefit to cost criteria and the strategy's potential to mitigate the impact from natural hazards. Consideration was also given to availability of funding, the department/agency responsible for implementation, and the ability of the locality to implement the project. Under each identified pre-disaster, applicable local government departments will be the lead in making sure that each project or action will be implemented in timely manner with other departments, other Roanoke Valley governments representatives and/or other regional agencies.

The anticipated level of cost effectiveness of each measure was a primary consideration when developing the list of proposed projects. Since the mitigation projects are an investment of public funds to reduce damages, localities have selected and prioritized projects based on the benefit to cost of each project in hopes of obtaining the maximum benefit. Projects were categorized as high, medium or low benefit to cost based on the available information for each proposed project. Reduced damages over the lifespan of the projects, the benefits, are likely to be greater than the project cost in all cases. Although detailed cost and benefit analysis was not conducted during the mitigation action development process, these factors were of primary concern when prioritizing and selecting the proposed projects.

Earthquake

Mitigation measures for earthquakes are region-wide recommendations for all localities adopting the Regional Pre-Disaster Hazard Mitigation Plan.

<u>Goal</u>: Increase public awareness of the probability and potential impact of earthquakes.
<u>Responsible Department(s)</u>: Community Development
<u>Strategy</u>:

1. Publish a special section in local newspaper with emergency information on earthquakes. Localize the information by printing the phone numbers of local emergency services offices, the American Red Cross, and hospitals.

Flood

Mitigation measures for floods are region-wide recommendations for all localities adopting the Regional Pre-Disaster Hazard Mitigation Plan. Localities have also developed locality specific goals and activities for this disaster that are listed in Chapter 7 Local Mitigation Strategies in this document.

Goal: Mitigation of loss of life and property from flooding and flood related disasters.
Responsible Department(s): Community Development, Transportation, Information Services
Strategies:

1. In cooperation with Federal and State governments, support a comprehensive public information and education program on all hazards addressed in the Regional Hazard Mitigation Plan. This can be accomplished through regional workshops and educational materials for citizens, business, local staff, and elected officials.
2. Develop and maintain an inventory of flood prone roadways in cooperation with local governments and the Virginia Department of Transportation.
3. Develop and maintain an inventory of flood prone critical regional facilities such as hospitals, public utility sites, airports, etc.

Goal: Update existing GIS data layers related to natural hazards.
Responsible Department(s): Information Services
Strategies:

1. Consider seeking funding and support programs that update FEMA's Flood Insurance Rate Maps (FIRM). Consider participation in FEMA's Cooperating Technical Partners (CTP) program that establishes partners with local jurisdictions to develop and maintain up-to-date flood maps.
2. In cooperation with local governments, utilize GIS to inventory at risk infrastructure and public and private structures within flood prone areas.
3. Participate in FEMA's Digital Flood Insurance Rate Maps (DFIRM) program.
4. Support FIRM remapping projects that address areas in the region that have the most serious mapping problems and where flooding is a repetitive problem.

Goal: Provide early warning of flooding

Responsible Department(s): Information Services

Strategy:

1. Identify areas with recurring flood problems and request additional IFLOW stream/rain gauges as appropriate to ensure that these areas are adequately covered and monitored.

Goal: Identify structural projects that could mitigate the impact of flooding.

Responsible Department(s):Community Development, Transportation

Strategies:

1. Consider seeking funding to prepare site-specific hydrologic and hydraulic studies that look at areas that have chronic and repetitive flooding problems.
2. Support Virginia Department of Transportation projects that call for improved ditching, replacement of inadequate and undersized culverts, enlargements of bridge openings and drainage piping needed to minimize flooding.

Hurricane

Mitigation measures for hurricanes are region-wide recommendations for all localities adopting the Regional Pre-Disaster Hazard Mitigation Plan.

Goal: Mitigate the impact of hurricanes in the Roanoke Valley-Alleghany Region.

Responsible Department(s): Community Development

Strategy:

1. Provide information about the *"StormReady"* program to each locality.

Karst

Mitigation measures for karst are region-wide recommendations for all localities adopting the Regional Pre-Disaster Hazard Mitigation Plan.

Goal: Improved Hazard Mapping and Assessments for karst areas and sinkholes.

Responsible Department(s): Information Services

Strategies:

1. Delineating karst areas and areas susceptible to sinkholes through a cooperative effort with the Virginia Karst Mapping Project, Virginia Speleological Survey, and Virginia Department of Conservation and Recreation (Virginia Cave Board).

Landslide

Mitigation measures for landslides are region-wide recommendations for all localities adopting the Regional Pre-Disaster Hazard Mitigation Plan.

Goal: Improved Hazard Mapping and Assessments for landslides.
Responsible Department(s): Information Services
Strategies:

1. Delineating susceptible areas and different types of landslide hazards at a scale useful for planning and decision-making, led by USGS and State geological surveys.
2. Work with state and Federal agencies to develop data that will assist in reducing and eliminating impacts from landslides.

Tornado

Mitigation measures for tornados are region-wide recommendations for all localities adopting the Regional Pre-Disaster Hazard Mitigation Plan.

Goal: Mitigation of the impact of Tornados.
Responsible Department(s): Community Development
Strategies:

1. In cooperation with Federal and State governments, support a comprehensive public information and education program on Tornados. This can be accomplished through regional workshops and educational materials for citizens, business, local staff, and elected officials.

Wildfire

Mitigation measures for wildfires are region-wide recommendations for all localities adopting the Regional Pre-Disaster Hazard Mitigation Plan.

Goal: Mitigation of the impacts of wildfire to life and property.
Responsible Department(s): Community Development, Information Services
Strategies:

1. Encourage residents and developers to use FireWise building design, siting, and materials for construction.
2. Conduct Community Wildfire Assessments in cooperation with VDOF staff using the Wildland Urban Interface Fire Protection Program's *Woodland Community Wildfire Hazard Assessment* form.
3. Identify buildings or locations vital to the emergency response effort and buildings or locations that, if damaged, would create secondary disasters in forested areas.
4. Apply for funds to assist in the implementation of wildfire mitigation measures, including many of those listed above, at the local level. National Fire Plan grant monies obtained by the Department of Forestry in the *Money for Mitigation* sub-grant program to at-risk communities.

Winter Storms

Mitigation measures for winter storms are region-wide recommendations for all localities adopting the Regional Pre-Disaster Hazard Mitigation Plan.

Goal: Mitigation of the effects of extreme winter weather.
Responsible Department(s): Community Development
Strategy:

1. Research and consider participating in the National Weather Service *"Storm Ready"* program.
2. Participate in special statewide outreach/awareness activities, such as Winter Weather Awareness Week, Flood Awareness Week, etc.

Roanoke Valley-Alleghany Regional Commission
Hazard Mitigation Projects in Need of State and Federal Assistance

Project	Hazard Mitigated	Benefit	Cost *	Benefit-to-Cost	Priority	Funding Partners	Implementation/ Lead Agency	Proposed Schedule
Flood hazard mapping update/ modernization (conversion of maps to DFIRMS)	Flooding	Increased accuracy of flood maps and more effective regulation and enforcement of regulations	$50,000	High	High	FEMA, VDEM	RVARC	12 – 24 Months
Seek funding to prepare site-specific hydrologic and hydraulic studies	Flooding	Inventory areas that have chronic and repetitive flooding problems; determine method to eliminate repetitive loss	$10,000	Medium	Medium	FEMA, VDEM	RVARC	24 months
Flood prone roadway study / database	Flooding	Inventory of flood prone roadways for planning purposes (road improvements, limitation of development)	$25,000	Medium	Medium	FEMA, VDEM VDOT	RVARC	12 months / Ongoing
Participate in FEMA's Cooperating Technical Partners (CTP) program and Digital Flood Insurance Rate Maps (DFIRM) program	Flooding	Increased accuracy of flood maps and more effective regulation and enforcement of regulations	$5,000	High	Medium	FEMA, VDEM	RVARC	Ongoing
Identify streams that need additional IFLOW stream/rain gauges	Flooding	Improved early warning of flooding; ensure that these areas are adequately covered and monitored	$2,500	High	Medium	FEMA, VDEM	RVARC	12 months
Identify funding and resources for delineating landslide hazards	Landslide	Tool planning and decision-making; limitation of new development.	$5,000	Medium	Low	FEMA, VDEM USGS VDOT	RVARC	24 months

Identify funding and resources for Hazard Mapping and Assessments for karst areas and sinkholes	Karst	Improved Hazard Mapping and Assessments for karst areas and sinkholes	$5,000	Medium	Low	FEMA, VDEM USGS Va DCR VDOT	RVARC	36 months
Public information and education program	All Hazards	Increased level of knowledge and awareness in citizens of natural hazards.	$10,000	Medium	Medium	FEMA, VDEM Local governments	RVARC	12 months
Community Wildfire Assessments	Wildfire	Identify buildings or locations susceptible to wildfires.	$5,000	High	High	FEMA, VDEM VA DOF	RVARC	36 months
Apply for funds to assist in the implementation of wildfire mitigation measures	Wildfire	Identify buildings or locations susceptible to wildfires.	$10,000	High	High	FEMA, VDEM Va DOF USFS	RVARC	24 months
Participate in special statewide outreach/awareness activities	All Hazards	Increased level of knowledge and awareness in citizens of natural hazards.	$5,000	Medium	Low	FEMA, VDEM	RVARC	Ongoing; annual
Provide localities with information about the Storm Ready program	Winter storms	Increased level of knowledge and awareness in citizens of natural hazards.	$2,500	Medium	Low	FEMA, VDEM	RVARC	12 months

*** Cost estimate is for funding to cover the staff time required from the Roanoke Valley-Alleghany Regional Commission only and does not include the cost of outside consultants, agencies or any cost for physical improvements.**

(BLANK)

Chapter 7

Local Mitigation Activities, Goals and Strategies, and Proposed Project Listings

(BLANK)

Chapter 8
Plan Maintenance

The Plan Maintenance section of this document details the process that will ensure that the Mitigation Plan remains an active and relevant document. The process includes a schedule for monitoring the Plan on an annual basis and producing the required plan revision every five years. This section describes how the localities will integrate the plan into their overall planning efforts.

Plan Adoption

The governing body of each locality will be responsible for adopting the Mitigation Plan. Each governing body has the statutory authority to promote actions to prevent the loss of life and property from natural hazards. The Roanoke Valley-Alleghany Regional Commission will be responsible for submitting the document to the Virginia Department of Emergency Management (VDEM). The VDEM will then submit the plan to the Federal Emergency Management Agency (FEMA) for review and approval. The review will be based on the federal criteria outlined in FEMA Interim Final Rule 44 CFR Part 201. Following FEMA review and approval, each participating jurisdiction will be required to formally adopt the plan.

Coordinating Body

The Regional Hazard Mitigation Committee will be responsible for coordinating undertaking of the formal annual and five-year review process. Each locality will designate the appropriate representatives to the committee.

In order to make this committee as broad and useful as possible, the Roanoke Valley-Alleghany Regional Commission will encourage other organizations and agencies to become involved in hazard mitigation. Possible additional representatives include: elected officials, insurance representative, Home Builders Association, Virginia Department of Transportation, railroad industry, gas and electrical utilities, and a local Red Cross representative.

The Hazard Mitigation Advisory Committee will meet no less than *quarterly*. These meetings will provide an opportunity to discuss the progress of projects and identify updates that may need to be made. The Roanoke Valley-Alleghany Regional Commission will serve as coordinator for the Committee.

Implementation through Existing Programs

Local governments have the statutory authority to implement many planning and mitigation goals through the Comprehensive Plan, Capital Improvement Plan, and Building and Zoning Codes. The Mitigation Plan provides a series of recommendations, which could be incorporated into the goals, and objectives of existing planning programs.

Upon adoption of the mitigation plan, localities will be able to utilize the Mitigation Plan as a baseline of information on the natural hazards that impact the region. These projects and action items identified in the Plan will help local governments develop planning documents that assist in protecting life and property from natural disasters. Local jurisdictions can use the annual Plan review as an avenue to update relevant sections of the Capital Improvements Plan (CIP) and incorporate mitigation activities. The Mitigation Advisory Committee will work with the local governments to insure that the hazard mitigation plan action items are consistent with the CIP and that they are integrated where appropriate.

The local building officials are responsible for administering the building codes. The Hazard Advisory Committee will work with other agencies at the state level to review, develop and ensure building codes that are adequate to mitigate or prevent damage by natural hazards.

Local governments should incorporate the relevant data, goals, actions and projects into their comprehensive plans. This can be accomplished through development of a hazard mitigation chapter for the plan or a series of sections in the plan that address specific hazards. A separate hazard mitigation chapter in the plan would provide a readily accessible source of hazard information for citizens and officials. Addressing hazards in each relevant section of the plan, such a flood prone roadways in the transportation chapter, would also be an effective method for documenting risk, potential loss and projects relating to hazard mitigation.

Evaluating and Updating the Plan

The Mitigation Plan will be evaluated on an annual basis to review progress that has been made on implementing the projects and to identify changes that could affect mitigation priorities. The convener, Roanoke Valley-Alleghany Regional Commission, will be responsible for contacting the Mitigation

Advisory Committee members and organizing the annual meeting. Committee members will be responsible for monitoring and evaluating the progress of the mitigation strategies in the Plan. The Committee will determine at the annual meeting if an update of the plan is needed. At a minimum, the plan will be updated every five years.

The committee will review the projects to determine if they are addressing current and expected conditions. The review will also consider state and Federal legislation that could affect the implementation of the plan. The committee will also review the risk assessment portion of the Plan to determine if this information should be updated or modified, given any new available data. The coordinating organizations responsible for the various action items will report on the status of their projects, the success of various implementation processes, difficulties encountered, success of coordination efforts, and which strategies should be revised.

Monitoring activities will include periodic reports by agencies involved in implementing projects or activities; site visits, phone calls, and meetings conducted by the Roanoke Valley-Alleghany Regional Commission; and the preparation of an annual report that captures the highlights of the previously mentioned activities.

The evaluation will utilize the following criteria:

1. That goals and objectives address current and expected conditions.
2. Changes in the nature, magnitude, and/or type of risks.
3. That resources were appropriate for implementing the plan.
4. Existence of implementation problems, such as technical, political, legal, or coordination issues with other agencies.
5. That outcomes have occurred as expected.
6. That agencies and other partners have participated as originally proposed.

Future updates of the Plan will incorporate the STAPLE+E technique for project prioritization and evaluation. This technique incorporates the following criteria:

S – Social	Mitigation actions are acceptable to the community if they do not adversely affect a particular segment of the population, do not cause relocation of lower income people, and if they are compatible with the community's social and cultural values.
T – Technical	Mitigation actions are technically most effective if they provide long- term reduction of losses and have minimal secondary adverse impacts.
A – Administrative	Mitigation actions are easier to implement if the jurisdiction has the necessary staffing and funding.
P – Political	Mitigation actions can truly be successful if all stakeholders have been offered an opportunity to participate in the planning process and if there is public support for the action.
L – Legal	It is critical that the jurisdiction or implementing agency have the legal authority to implement and enforce a mitigation action.
E – Economic	Budget constraints can significantly deter the implementation of mitigation actions. Hence, it is important to evaluate whether an action is cost-effective, as determined by a cost benefit review, and possible to fund.
E – Environmental	Sustainable mitigation actions that do not have an adverse effect on the environment, that comply with Federal, State, and local environmental regulations, and that are consistent with the community's environmental goals, have mitigation benefits while being environmentally sound.

The Hazard Mitigation Advisory Committee will also notify all holders of the regional plan when changes have been made. Every five years the updated plan will be submitted to the Virginia Department of Emergency Management and the Federal Emergency Management Agency for review.

Public Involvement

Roanoke Valley-Alleghany Regional Commission and the local governments of the region are dedicated to involving the public directly in review and updates of the Hazard Mitigation Plan. The public will also have the opportunity to provide feedback about the Plan. Copies of the Plan will be catalogued and kept at all of the appropriate agencies.

In addition, copies of the plan and any proposed changes will be posted on the Roanoke Valley-Alleghany Regional Commission website. This site will also contain an email address and phone number to which people can direct their comments and concerns. Public meetings will also be held in conjunction with each annual evaluation or when deemed necessary by the Hazard Mitigation Advisory Committee. The meetings will provide the public a forum for which they can express its concerns, opinions, or ideas about the Plan. Local Public Information Officers will be responsible for publicizing the annual public meetings and maintaining public involvement through the public access channel, web page, and newspapers.